**Historic, archived document**

Do not assume content reflects current scientific knowledge, policies, or practices.

Files

CENTRAL STATES
FOREST EXP. STA.

# DIVISION OF WATERSHED MANAGEMENT RESEARCH

1958 JUN 20 AM 8 51

## Semiannual Report

FS History Office
Reference Shelf

No. Rec'd. 8
Centers
Director
Editor
Statistician
Disease
Economics
Insect
For. Mgmt.
Utilization
W/S Mgmt.
Adm. Off.
Adm. Asst.
Payroll
Personnel
Purchase
Property
Travel
File

U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE

October 1957 - March 1958

SEMIANNUAL REPORT
Division of Watershed Management Research
October 1957 - March 1958

Table of Contents


| | Page |
|---|---|
| **Washington Office** | |
| Annual vs. Semiannual Reporting? | WO-1 |
| Discussion | WO-2 |
| Publications | WO-4 |
| Some References of Interest | WO-4 |
| Notes on Intrumentation and Computers | WO-5 |
| **California** | |
| General | CAL-1 |
| Personnel | CAL-1 |
| Publications | CAL-2 |
| Manuscripts published | CAL-2 |
| Manuscripts accepted for publication | CAL-2 |
| New manuscripts | CAL-3 |
| Current Research | CAL-4 |
| San Dimas | CAL-4 |
| Watershed management tests to increase water yield | CAL-4 |
| Soil sterilant tests | CAL-4 |
| Record on collection reduced | CAL-4 |
| Snow studies | CAL-5 |
| Meetings | CAL-5 |
| Visitors | CAL-6 |
| **Central States** | |
| Athens Research Center | |
| Effects of converting ridge sites to pine on the Vinton Furnace Exp. Forest | CS-2 |
| Litter | CS-2 |
| Surface water runoff from small plots | CS-2 |
| Soil moisture | CS-3 |
| Soil moisture levels for common vegetal cover types in Southeastern Ohio | CS-3 |
| Coshocton Hydrologic Laboratory | |
| Effects on streamflow by changing forest type of vegetation grass to trees | CS-4 |
| Maximum storm flow tabulations. WS 172 | CS-5 |
| Berea Research Center | |
| Strip mine study. Cumberland National Forest | CS-5 |
| Columbia Research Center | |
| Hydrology of small drainages | CS-6 |
| Maximum storm flow tabulations. Green Acre Watershed | CS-6 |
| Cooperative aid study - rocky soils in Missouri Ozarks | CS-6 |
| Meetings and talks | CS-7 |


(Over)

Central States (Cont'd) Page

Publications ..... CS-8
Instrumentation ..... CS-8
A. Continuous conductivity recorder for measuring sulfate concentration, pH, and dissolved solids.

Intermountain

General Information (Division) ..... INT-1
Personnel assignments ..... INT-1
Publications and manuscripts ..... INT-2
Boise Research Center, General ..... INT-2
Logging road reseeding study ..... INT-2
Great Basin Research Center, General ..... INT-3
Snow control study ..... INT-3
Equipment design study ..... INT-3
Missoula Research Center, General ..... INT-3
Erosion and sediment study ..... INT-4
Manuscripts ..... INT-4
Nevada Research Center ..... INT-4
Problem analysis continuation ..... INT-4
Research Center office moved ..... INT-5
Meetings attended ..... INT-5
Wasatch Research Center ..... INT-5
Parrish Canyon streamgaging station ..... INT-5
Water use study ..... INT-6
Parrish runoff plots ..... INT-6
Plot establishment and treatments ..... INT-7
Precipitation, runoff, and erosion ..... INT-8

Lake States

General ..... LS-1
Publications ..... LS-1
Program ..... LS-1
Headwaters Research Center ..... LS-1
Snow samples ..... LS-1
Soil moisture samples ..... LS-2
Experimental areas ..... LS-2
Manuscripts ..... LS-2
Lower Peninsula Research Center ..... LS-2
Project analysis ..... LS-2
Soil moisture samples ..... LS-3
Snow and frost samples ..... LS-3
Driftless Area ..... LS-5

Northeastern

General ..... NE-1
Kingston ..... NE-1
Leading Ridge Watershed ..... NE-1
Snow in the Poconos ..... NE-1
Soil moisture study ..... NE-2

Page

Northeastern (Cont'd)

Soil survey ..... NE-2
Watershed calibration ..... NE-2
Miscellaneous ..... NE-2
Mountain State Research Center ..... NE-3
Snow on the Fernow ..... NE-3
Soil moisture measurement ..... NE-3
More water quality data ..... NE-3
Surveys and computations ..... NE-4
Thanks, fellows ..... NE-4
White Pine-Hardwood Research Center ..... NE-4
Snow at Hubbard Brook ..... NE-4
Integrated plot study ..... NE-4
Weirs, road, and laboratory ..... NE-5
Compilation ..... NE-5
Soil moisture measurement discussion ..... NE-5
Publications ..... NE-5
Manuscripts submitted ..... NE-6

Pacific Northwest

General ..... PNW-1
Cooperation ..... PNW-1
Training ..... PNW-1
Willamette ..... PNW-2
General ..... PNW-2
Watershed studies ..... PNW-2
Landslides ..... PNW-3
Interception study ..... PNW-3
Siskiyou-Cascade ..... PNW-4
A flow divider for use on runoff plots ..... PNW-4
Let's have more basic research ..... PNW-4
Blue Mountain ..... PNW-6
Snow reconnaissance study ..... PNW-6
Skid trail-runoff ..... PNW-7
Mid-Columbia ..... PNW-7
Soil disturbance due to logging ..... PNW-7
Miscellaneous ..... PNW-8
Bull Run Project ..... PNW-8
Gaged watersheds ..... PNW-8
Research as a cooperative endeavor ..... PNW-8
Erosion from logging ..... PNW-9
Strip-cutting ..... PNW-9
Miscellaneous activities ..... PNW-9
Publications ..... PNW-9

Rocky Mountain

Albuquerque ..... RM-1
Accuracy of sediment sampling ..... RM-1
Soil moisture at Pine Flat ..... RM-2
New publications ..... RM-3

Page

Rocky Mountain (Cont'd)

Flagstaff ..... RM-4
Beaver Creek project ..... RM-4
Other work ..... RM-4
Snow pictures ..... RM-4
Fort Collins ..... RM-5
A comparison of estimated and measured melt water production from alpine snow during the summer ..... RM-5
Fraser Experimental Forest ..... RM-6
Fool Creek ..... RM-6
Snow evaporation and sublimation ..... RM-6
Grand Junction ..... RM-6
Black Mesa watershed studies ..... RM-8
Rapid City ..... RM-9
Soil moisture ..... RM-9
Soil compaction ..... RM-10
Tempe ..... RM-10
Measurement of evapo-transpiration in the field ..... RM-10
Ecology of phreatophytes ..... RM-11
Tamarisk and soil salinity ..... RM-12
Timber harvest in mixed conifer forest has little effect on streamflow ..... RM-13
Forest and chaparral roots penetrate deeply into the soil mantle ..... RM-13
Water increases accompany conversion from chaparral to perennial grass ..... RM-14
Preliminary runoff from ponderosa pine watersheds ..... RM-14
Shrub recovery and grass regeneration following burning on Mingus Mountain ..... RM-15
Cooperative chaparral watershed-game management study on 3-bar unit ..... RM-16
Additional watersheds under construction in the chaparral type ..... RM-16

Southeastern

Coweeta Hydrologic Laboratory ..... SE-1
Progress on Coweeta studies ..... SE-1
Interception in a cove hardwood stand ..... SE-2
Weather ..... SE-3
Meetings and training sessions ..... SE-3
Visitors ..... SE-3
Publications ..... SE-4
Piedmont Research Center ..... SE-5
Soil moisture studies ..... SE-5
Soil fauna project ..... SE-8

Southern

General ..... SS-1
Personnel ..... SS-1
Publications ..... SS-1

Page

Southern (Cont'd)


Central Ozarks Research Center ..... SS-3
Watershed studies ..... SS-3
Soil moisture studies ..... SS-4
Tallahatchie Research Center ..... SS-5
Watershed studies ..... SS-5
Land rehabilitation studies ..... SS-6
Soils and soil moisture studies ..... SS-8
Vicksburg Research Center ..... SS-10
Use of I.B.M. Model 650 digital computer ..... SS-10
Solar radiation and soil moisture depletion ..... SS-12
Sampling and soil variability ..... SS-15

## Index to Line Projects Discussed in this Report*

| Line Project | Pages on which line project discussed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | AL | CAL | CS | INT | LS | NE | PNW | RM | SE | SS |
| FS-1-w1-1 | | | | | | | | | | |
| 2 | | | | | | | 6 | | | |
| 3 | | | | | 1,3,4 | | 3 | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | 2,3 | | | | | |
| 7 | | | | | | | | | | |
| FS-1-w2-1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| FS-1-w3-1 | | | | | | | 4 | | | |
| 2 | | | | | | | | | | |
| FS-1-w4-1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| FS-1-w5-1 | | | | | | | | | | |
| 2 | | | | | | | 2,7,9 | | | |
| 3 | | | | | | | 2 | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| FS-1-w6-1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | | | | |
| FS-1-w7-1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
| 4 | | | | | | | 9 | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | 2,8 | | | |

*Information incomplete in this report. Mainly for illustration.

FOR IN-SERVICE USE ONLY

# SEMIANNUAL REPORT
## Division of Watershed Management Research
## October 1957 - March 1958

### Washington Office

Herb Storey, Clark Holscher, Les Harper and others have labored diligently developing material in line with a proposal by the Director-General of the Food and Agriculture Organization that the United States play host in 1959 to a study tour on watershed management. The proposal has not yet been given official approval, but if it is accepted this Division will be prominently involved. The project would run for about 8 weeks and the tour would cover both East and West. In the USDA the SCS and ARS would participate as well as agencies from the Department of the Interior, State, Corps of Engineers, and TVA. If the project materializes you will probably hear more about it.

The pilot area soils program under Retzer's immediate direction is being extended to Regions 7, 8 and 9. Every western region has at least one such area and some have as many as three for testing procedures in different kinds of landscapes. Only one unit has been completed down to the final land management plan (prepared by the ranger with assistance from the soil scientists) but we expect to see several more completed this coming winter.

The CIA member of the AGU Committee on Evaluation of Soviet Hydrology, of which Frank is a member, has made available translation of a 6-page article "Work of Soviet geophysicists on problems of hydrology," and of another article "Reports on scientific work in hydrology," which lists 562 titles of recent publications. We have requested translations of over 100 of the articles so listed--assuming such translations are or can be made available--and are keeping our blood pressure down until a reply is received. At that time we will arrange to duplicate the short translations mentioned above and to route copies of any of the other translations we may be fortunate enough to obtain.

During October Frank conducted a GFI of the CS. During February he was loaned to the Joint Congressional Committee on Metropolitan Washington Problems as a water consultant. Frank has also represented the Wilderness Society on the General Planning Committee of the National Watershed Congress and on the Board of the Water Resources Council.

Annual vs. Semiannual Reporting?

A suggestion has been made that the October-March issue be discontinued because the project status sheets are also submitted at about that time, hence posing a question of duplication of material. If the Semiannual Report represented only an informal version of the project status sheet, the point would be well taken. However, the report has a quite different purpose and we had hoped that the difference would remain abundantly clear to all watershed researchers who read it. That purpose is to provide a strictly "in-research" forum whereby researchers can freely express ideas--however chimerical or inelegant--raise questions or comment on theories, hypotheses, analytical or instrumental techniques, etc. We've enjoyed

some fine discussions and contributed thereto ourselves on occasion. Some of these discussions have led to exchanges of thoughts by informal correspondence beyond what has appeared in the reports. How stimulating and otherwise effective they will continue to be will depend, of course, on what our field personnel want to make of it, and especially on the freedom which they feel they can continue to have to "let their hair down" on the wide range of technical matters--many far from jelled as to principle or techniques--with which watershed management research necessarily concerns itself.

Let's have the benefit of your thoughts on this question. -- Herb Storey

Discussion

I realize that the semiannual reports are not intended to be complete or refined, but now and then one's curiosity does get aroused enough to want to see a bit more detail about some experiment described in the report. A few examples will illustrate what I mean.

INT

Page 2 - Study No. 3: How many pounds per acre or inches depth did the wood chip mulch amount to? Study No. 4: What was the basis for using 20-20-0 fertilizer and for the rate applied? Might the results indicate the possibility of using annuals or even forbs or legumes to establish a cover, assuming the main purpose is to stabilize the area and improve conditions for the return of tree growth on the abandoned log roads?

Page 6, 3d par. re discrepancy between aspen and brush and water use - Assuming root depths in both cases reach 6 feet, differences might be accounted for either by volume of soil occupied by respective root systems, by physiological differences between the brush and aspen, or possibly even by differences in precipitation between the 2 sets of plots. The physiological aspect seems worth exploring with plant physiologists. Of course, it is possible that large sampling errors may also be responsible for the apparent discrepancy.

LS

Page 1, last par. - Presumably conifers are referred to or is that assumption incorrect? The last sentence apparently assumes that temperatures will remain continuously low until the late spring snow storms or early rains occur. If data are available it would be interesting to determine the recurrence intervals of such low temperatures.

NE

Page 5, 2d par. - Would comparison of the march of soil moisture between cut and uncut stands yield a further clue to the significance of interception as a factor in evapotranspiration?

SS

Page 3 - Data to be collected from the conversion plots do not seem complete enough to provide really significant results, since apparently they omit measurements of total water yield or at least soil moisture fluctuations and seepage as indications of changes in the amount of water which would become available for streamflow. The study does not thus appear to provide a basis for evaluating all the significant effects of conversion and grazing upon the soil hydrologic properties.

/Note - However, project status sheet FS-1-w5-6-SS does definitely indicate that the additional data will be collected. I presume this description is the more complete one. Maybe a word or two to that effect would have cleared matters./

Page 8, Post-hole plantings - What is the basis for using "commercial" fertilizer? Were nutrient requirements determined as a basis for selecting fertilizers containing minerals in which the soil is most deficient? (See comment below under Fertilizers.)

Use of wetting agent - "It is hoped that the wetting agent will permit summer showers to move readily into the soil even on dry eroded sites..." What about water spreading on mulched areas in order to achieve a ponding effect and thus induce percolation? This practice might be applied concomitantly with and without the wetting agent.

Page 10 - "Inherent physical characteristics..." Could we test different soils in different conditions to obtain quantitative erosion values, then try to explain these values in terms of colloidal content, etc.? We might thus go backwards from there to get at the basic factors of resistance to displacement and to transportation, respectively. Among the factors to examine might be the distribution of pore sizes in the surface layer as well as the degree of aggregation, percent of silt plus clay, and percent of organic matter before and after rainfall impact, respectively.

Fertilizers - How adequate are our determinations of fertilizer requirements in terms of (a) soil mineral deficiencies, (b) plant nutrient requirements, (c) mixtures designed specifically to meet the needs of the plants to be tested? Perhaps one reason for the inconclusive results frequently reported in the forestry literature may lie in the extent of our efforts to answer such basic questions.

Do we need a program of field trials to develop experience of what different mixtures can do for given species on given soils? I think we do. Meantime, I suggest that in all cases where fertilizers are applied, definite reasons be given for selecting the mixtures and rates used. In this way we can all derive the maximum values from our work for the benefit of other investigators as well as ourselves. Since agronomists have had considerably more experience than we've had in mixing fertilizers and in sampling soil-plant conditions, we might obtain some good leads from our associates in that field.

Might it be advisable to set up an ad hoc committee of 2 or 3 to check up on current experimental methods and techniques applicable to the kinds of tests we are most concerned with, and to report back, with recommendations, in our next semiannual report? --Bernard Frank

Publications

Conservation and recreation in a comprehensive program for the Potomac River Basin with special reference to the National Capitol Region. Staff Report by Bernard Frank for the Joint Committee on Washington Metropolitan Problems. 85th Cong., 2d Sess., March 1958. 21 pp. illus. U. S. GPO.

Some References of Interest

Jones, R. L. The effect of surface wetting on the transpiration of leaves. Physiologia Plantorium. 1957. 10(2): 281-288.

Wilde, S. A. Forest Soils. 1958. "Use of fertilizers for improvement of forest stands and plantations." pp. 449-459.

L. J. Webb (Division of Plant Industry, Brisbane)

Attention is drawn to the role of trees, particularly on wet highlands of eastern Australia, in regulating stream flow and influencing soil fertility. If, as Dr. Bonner suggested, one of our problems is to "get more water" then surely we should use wisely what we have: this involves scientific integration of forestry and agricultural practices.

Our thinking about water relations should include conditions of water excess which, as well as drought, involves stress. Excessive conditions occur not only in the wet tropical lowlands of North Queensland but also in sub-coastal, even "semi-arid" sub-tropical regions during the wet season. Here, indigenous plants are adapted to both water-logging in March and desiccation in November.

Anatomical adaptations such as dual root systems e.g. Mulga, may be evident although we are largely ignorant of the root systems of our native plants. In any case, this ecological versatility raises many interesting physiological problems; e.g. how does a plant get along in too much water? In swampy places and the wetter kinds of rain forests, plant roots are in a medium rich in carbon dioxide. What is the possibility of carbon dioxide being taken up and fixed by roots? Development of such an ability is an alternative to the mechanism of carbon dioxide fixation by succulents in the dark already mentioned by Dr. Bonner, as a solution of the problem of $CO_2$ exclusion by cuticles required to reduce evaporation from leaves during the day. It is thought that studies of plant water relations at the extremes of the soil moisture range will be necessary for full understanding.

J. Bonner replied that Russian workers claimed that soil $CO_2$ could supply much of the $CO_2$ requirements of the plant, but since the $CO_2$ requirement was so high it was unlikely that soil $CO_2$ could maintain the supply. Bonner also replied that water conservation (at least in its engineering aspects) was the concern of others, but agreed that it was important in the total water picture in Australia. (pp. 119-120)

--Water Relations of Plants. Proceedings of a Symposium held in Canberra, September 1956. Commonwealth Scientific and Industrial Research Organization, Australia. Melbourne 1957.

Notes on Instrumentation and Computers

Ed Johnson has written us on an aspect of instrumentation that we think you'll be interested in following up on.

> The September 1957 issue of Proceedings of the American Society of Civil Engineers, Irrigation and Drainage Division, just arrived from the U.S.D.A. Library. There is an excellent article "Common Errors in Measurement of Irrigation Water" by Charles W. Thomas, Proceeding Paper 1362, 24 pages. This article calls attention to errors that result when deviating from standards. The magnitude of errors resulting from changes in certain dimensions, incorrect settings, changes in flow patterns, and other deviations is evaluated for some of the commonly used measuring devices.
>
> An article of this type in the reference files would have answered many questions and helped with training of new technicians during my assignment at the Intermountain, Southeastern and Central States Stations. I would like to propose that each of our Stations with a stream gaging program obtain copies of Thomas' article for each Center having gaged watersheds.

The following memos by Whelan and Lull deal with recording and computing of streamflow data.

> Report on Don Whelan's discussion with Roy Carter of U. S. Geological Survey about electronic recording and computing of streamflow data. 6/28/57
>
> The USGS operates over 6,000 stream gages and they are much interested in determining the most economical, efficient and accurate process for recording and computing streamflow. The USGS has expended over $100,000 in the last two years in developing a Special Purpose Computer. Due to technical difficulties they have not been able to make it work satisfactorily and have abandoned it. The equipment consisted of a scanner and a function generator. By using 44 knobs, 22 points could be set to define the stage-discharge curve. The scanner picked up 100 points on the stage hydrograph chart, converted them to discharge, and summed up the values to give the mean daily

discharge. The difficulty that could not be overcome was that the scanner became confused by imperfections in the paper and the generator would drift off and stop.

The USGS is ready to start on an entirely different process and will investigate it on a large scale. The proposed system will consist of (1) shaft input digital recorder at each stream gage to obtain a digital record of stage in binary decimal form at discrete time intervals, (2) translators which will automatically convert the binary code to the serial type input required for computers, and (3) table lookup computers which would compute values of mean daily discharge from the record of stage and the stage-discharge function.

The Digital Demand Recorder and Translator Unit are made by the Fischer & Porter Co., Hatboro, Pennsylvania. The recorder is made to work on an external 24 volt d-c battery supply. It is estimated that the batteries will last about one year. The recorder is so constructed that it will accept the shaft rotation of the float assembly of the Leupold & Stevens A-35 strip chart recorder as the input signal. The Digital Recorder will be used to replace the Stevens Recorder in the gage house. The binary decimal code enables visual interpretation of the record by relatively inexperienced personnel. The USGS plans to buy a large number of the Digital recorders in May 1958 and a few Translator Units. The readout interval of the recorder can be set anywhere between 10 seconds and 15 minutes. The USGS plans to operate both the digital recorder and the Stevens recorder simultaneously on several hundred stations on an experimental basis.

The costs of the instruments are about as follows:
Digital Demand Recorder - $500 now and $350 when in production
Translator Unit - $5,000 for complete purchase of unit
LGP-30 table lookup computer (Burroughs Adding Machine Co.) or equivalent - rented at the rate of $1,400 per month.

Specifications for digital recorders

1. Input. The Digital Recorder shall accept the shaft rotation of the float assembly of the Leupold & Stevens A-35 strip chart recorder as the input signal. The contractor shall furnish the proper mechanical connection to the float assembly.

2. Range. 8,000 counts corresponding to readings from 0000 to 7999.

3. Accuracy. Data are to be recorded to the nearest single count.

4. Input Torque. One inch ounce or less.

5. Electrical requirements. Not more than 50 watt-seconds per readout with power supplied by 6-volt dry battery.

Housing. The recorder shall be enclosed in a drip proof, weather proof metal case. A glass in the door to permit visual inspection of the punch and paper tape record without opening the case shall be provided. The case shall not be larger than 13" x 12" x 7".

Materials. All parts of the instrument shall be fabricated from materials which will resist indefinitely corrosion by natural humidity conditions of 100% relative humidity.

Ambient temperature range. -40°c through +50°c.

Humidity. 10 to 100% relative.

Readout. The readout shall be in a binary decimal code on punched paper tape. The punched paper tape shall not be more than 2-1/8 inches wide and suitable for direct reading on a 16 channel tape reader.

The readout will be initiated by means of an external contact closure.

Advance of tape. The tape will be automatically advanced a distance of not more than 1/8 inch after each readout.

Clock. The clock assembly to initiate readouts will be furnished by the Government.

Reliability. The Digital Recorders shall satisfactorily operate and readout 35,000 consecutive times in environment testing when signals to the Recorders for readout are spaced at intervals of 90 seconds.

Specifications for translations

Translator shall read paper tape as punched by the Digital Recorder and shall provide an output signal to punch tape in standard serial-by-character form, at the standard 10-characters per inch spacing, on standard 5,6,7, or 8 channel tape at the rate of 10 characters per second or faster. The character coding shall be easily changeable by plug board or terminal strip to fit any 5, 6, 7, or 8 channel code desired. Provision shall be made for adding 1 or 2 constant characters at the end of each group of variable characters representing one gage-height reading, the constant characters shall be easily changeable by plug board or terminal strip. Provision shall also be made for filling in as many as 7 zero-coded characters ahead of each group read from the Digital Recorder tape to produce a complete computer word of up to 13 digits for each gage-height reading, to fit the input requirements of certain general-purpose computers. In addition, the translator shall have provision for insertion of one complete computer word (up to 13 serial characters) to indicate the date at the beginning of each group of readings representing samples for one calendar day. The date indicator shall be originally set by the translator operator for the first day of a sequential period of tape to be

translated and shall automatically be increased by one by the translator for each successive group in turn, by counting the number of readings read from the Recorder tape. The total number of readings representing one calendar day shall be changeable by the translator operator to 24, 25, 48, 50, 96 or 100. An indication of the number of readings counted since the last end-of-day indicator shall be visible to the translator operator and resettable.

Memo. Howard W. Lull to Director, NE (RI-NE-METHODS-General) 5/14/58

Ken Reinhart, Dick Sartz, and I spent the week of April 13 at the Fernow, Coweeta, Asheville, N. C., and the Washington Office checking on methods of speeding up the compilation and analysis of our watershed data. A great part of the afternoon and morning at Coweeta was spent in trying out the discharge integrator, an instrument that permits rapid computation of daily streamflow. Also at Coweeta, we discussed with H. G. Meginnis, Don Whelan, and John Hewlett the types of analyses conducive to machine computations. At Asheville, Ken Reinhart checked with the Geological Survey on their procedures and recommendations for using the discharge integrator, and we spent a few minutes with some of the Station's staff and the Director. At the Washington Office we spent an afternoon with Ted Osborne and Herb Storey describing the type of data we have and the kind of analyses we would like to make and getting Osborne's ideas on the use of electronic equipment. We spent the following morning with Mr. E. L. Simpler, Special Government Representative for the IBM Corporation, who described some of their equipment which might be useful in our work. Dick Sartz had not visited the Fernow nor Coweeta before; we spent one-half day at the Fernow on a show-me trip and he also took a quick tour of the Coweeta installations.

In our discussions of handling watershed data, it soon became obvious that two separate procedures were involved: first, we need something like a discharge integrator to compute rapidly from the chart daily discharges in c.s.m.; second, we should utilize high-speed methods of analyzing these data.

During our tour, we checked on the first procedure at Coweeta and Asheville and dealt with the electronic computers at the Washington Office.

Discharge Integrator

The discharge integrator is an instrument that computes daily streamflow as a pointer is run over the hydrograph trace. Before it can be operated on charts from any one weir, the rating curve for the weir must be set into the machine, a process that takes from one to four hours. After this is done, the pointer is run over the hydrograph trace and at each midnight line a summation value is read from the dials which gives the total discharge up to that point. Subtracting midnight values gives the daily discharge. This instrument cannot be used, by nature of its construction, on heads below 0.2 of a foot on the FW-1 chart and 0.1 a foot on the A-35 charts. The integrator costs $1,800 and can be operated by clerical personnel.

The major advantage of the integrator is speed. With heads above the 0.2 or 0.1-foot levels, one year's record from one weir could be computed in one day after the charts had been inspected for time and head corrections. Computing the same record with present methods of point-picking and use of Form 6 for compilation and computations would require perhaps two weeks or longer. Use of the integrator would do away with Form 6, cutting in half the forms for filing. Accuracy might be gained because fewer numbers are handled; also, it should simplify checking of daily streamflow values.

Off-setting this advantage of speed is the fact recently reported by Reinhart that over half of the hydrograph breaks (marking time intervals for different rates of discharge) on the FW-1 charts occur at heads below 0.2 foot. The number of breaks at low flows could be reduced, as Reinhart points out, if we are willing to accept a lower standard of accuracy. This question deserves further study.

We agreed that the discharge integrator should be given a thorough trial at the Fernow and Hubbard Brook. This trial should consist of time and accuracy tests against present methods of handling the data. How to handle chart expansion corrections will have to be considered. For these tests instruments should be borrowed from the Geological Survey.

The following action will be taken:

1. The Upper Darby office will write to the Harrisburg district and request loan of an integrator for a period of 30-60 days for the use of at the Fernow.

2. Hubbard Brook will write to the Boston district of the Geological Survey or the Hartford office for loan of an instrument. In event these instruments cannot be borrowed, perhaps arrangements can be made to take the data to the Geological Survey Office for testing.

3. The Upper Darby offices should write to the IBM Corporation and secure information on the development of an instrument to compute and tabulate daily streamflows on punch cards.

4. Finally, if the discharge integrator is judged useful, one should be purchased for Station use with all watershed centers chipping in. If the discharge integrator does not appear to be useful, possibilities of punch-carding the data as read from streamflow charts should be explored. Osborne indicated that the number of cards needed to punch one for each time interval would not be far-fetched.

When writing to the Geological Survey offices, Bernie Frank suggested that we state that information on the location of the instruments was given to us by Mr. Ade Williams of the Washington Office of the Geological Survey in the hope that we would be able to borrow an instrument from a District Office.

## Electronic Computers

Electronic computers can do in a few minutes analyses that would require months of computation using ordinary desk equipment. They permit full use of the data and allow complicated analyses and re-analyses that would not ordinarily be undertaken with present machines. Before these electronic computers can be used, the data, of course, must be compiled--in itself a major undertaking when several variables are involved. Then, the analysis must be programmed which simply means setting up the operating instructions for the analysis. Costs of programming are high and can run to several thousand dollars for a complicated analysis. However, many of the common analyses have already been programmed and may be borrowed without charge. Aside from programming, the use of the machine may cost perhaps $250 for a complicated analysis.

Analyses made by Reinhart for calibration of the Fernow watersheds are neither voluminous nor complicated enough to justify use of electronic equipment. The multiple-regression analyses that have occupied most of Reigner's time in the last two years would be adaptable to these machines. Following are a number of analyses which could be handled by the electronic computers:

1. Multiple regression of the single-watershed calibration type in which three or more independent variables are used. With machine help, we could conduct this type of analysis for all our experimental watershed data. This would permit a check on control-watershed calibration analyses and a better understanding of the variables associated with changes in streamflow.

2. Computation of flow duration curves. This is a major analysis in which the percentage of time that specific discharges occur is computed.

3. Predicting daily flow of one watershed from another on an annual, seasonal, and monthly basis.

We concluded that no major computations would be started without first investigating the use of electronic equipment. As a starter, we agreed that Fernow, Hubbard Brook, and Dilldown should each compile a list of major analyses that they would like to have made with an estimate of how long it would take to compile the data and when each analysis should be made. We also agreed that each watershed center should submit one major analysis, background for one major research paper, for immediate consideration. We will go over these with Al Bickford and investigate facilities and costs. Mr. D. Collishaw is the Philadelphia representative for the IBM Corporation.

At the Washington office, Mr. Simpler of the IBM Corporation described a water-level recording system which would automatically punch card streamflow data. Data from streamflow recorders could be brought into the IBM equipment through a wiring system. Equipment for a hook-up of 8 to 12 stream gages could be rented for about $300 a month. Offhand, it seems to be a complicated system to operate and

would be liable to break down during storm-data periods. Right now, we agreed that the money we have could be better spent in analyzing data than in an automatic system for recording it. Hubbard Brook may check on this again after more weirs are built.

This memorandum has been reviewed by Reinhart, and Sartz and we suggest that copies be sent to the Washington Office, Coweeta, Kingston, State College and Central States (Ed Johnson) for their information.

# SEMIANNUAL REPORT

Division of Watershed Management Research
California Forest and Range Experiment Station

October 1957 through March 1958

## GENERAL

Rainfall during the current winter up to April 8 at Tanbark Flat totals 47.15 inches. The 29-year average is 26.81 inches for the hydrologic year. Streamflow has been consistently above that of the last few years, but peak flows have been moderate due to well spaced storms with only low to moderate rainfall intensities. Temperatures have been above average for the winter. There has been no surface runoff from the brush, grass, and pine covered plots at Tanbark Flat. Seepage has started from all of the vegetated large lysimeters but there has been no seepage from the bare tank.

Contributions to the Colman Watershed Fellowship Fund now total $20,123.50.

## PERSONNEL

Constance A. Keller, Division Clerk, and Adrienne T. Giles, Clerk-Typist, are the new secretarial team in the Berkeley office. Both joined our group in January. Constance is an old hand in forestry, after 23 years on the Siskiyou and Six Rivers National Forests. Adrienne was with the Alameda Naval Air Station before coming to the Forest Service.

Henry Anderson and Ray Rice received incentive awards of $200 and $75 respectively for superior services in snow management research.

Clark Gleason spent 7 weeks in Washington working as a Manual-Handbook detailer on the Watershed Management Handbook.

Gil Clark, Superintendent of the Central Sierra Snow Lab, broke his leg while week-end tobagganing. At present he is assisting Cliff Mansfield in equipment development in Berkeley. His wife, Lotte, is assisting in data analysis, also in Berkeley.

Forestry students Norden Cheatham and Richard Dresser are working part-time during the school year at Berkeley, analyzing hydrographs and computing meteorological data for the snow hydrology studies.

Dean Dibble, Forestry Aid from the Division of Forest Fire Research has joined us at San Dimas for 3-1/2 months to assist with the new water yield studies.

Edward Karman and Frank Scott from the California Division of Forestry have spent 2 weeks each at San Dimas to aid in the water yield studies and gain experience. This cooperation from the California Division of Forestry is to be continued by the assignment of men from other districts in the state.

Helen Bell, Statistical Clerk, is employed temporarily at San Dimas to aid in the processing of data for publications.

## PUBLICATIONS

### Manuscripts Published

"Research by the U. S. Forest Service, San Dimas Research Center" by P. B. Rowe, Proceedings, Conference on Sediment Problems in California, Committee on Research in Water Resources, University of California, Berkeley, California, pages 23-25, November 26-27, 1956--briefly describes erosion problems of southern California mountain watersheds, erosion research at the San Dimas Research Center and research needed.

"More good water--research at San Dimas Experimental Forest applying fundamentals to entire watersheds," by Walt Hopkins, Calif. Forest and Range Exp. Sta., Misc. Paper No. 22. 6 pp., illus., March 1958. Discusses progress and reorientation of San Dimas research program.

"Relating sediment yield to watershed variables," by H. W. Anderson. Trans. Amer. Geophys. Union 38(6):921-924, 1957. (Description in April 1956 Semiannual Report, p. 2).

"Watershed management--an annotated bibliography of erosion, streamflow, and water yield publications by the California Forest and Range Experiment Station" by Clark H. Gleason, CF&RES Tech. Paper 23, 79 pp. Illus. January 1958.

"Soil-vegetation survey of a Central Sierra Snow Zone Watershed," by R. E. Nelson. CF&RES Misc. Paper 21, 43 pp. illus., Dec. 1957.

"Snow on forested slopes" by H. W. Anderson and T. H. Pagenhart. 25th Ann. Western Snow Conf. Proc. pps. 19-23, 1957.

"Wind direction during snowfall at Central Sierra Snow Laboratory" by Arnold Court. 25th Ann. Western Snow Conf., Proc. pp. 39-43, 1957.

"New meteorological and snow studies in the Central Sierra" by K. J. Walsh. 25th Ann. Western Snow Conf., Proc. pp. 43-45, 1957.

"Snow surveys from the snow surveyor's side" by P. J. Wyckoff, 25th Ann. Western Snow Conf., Proc. pp. 57-59, 1957.

### Manuscripts Accepted for Publication

"Reversal indicator for a water level recorder" by L. A. Andrews. Describes a pen attachment for installation on Friez FS-1 water level recorders to indicate reversals of the water level recording pen. Manuscript has been submitted to Engineering News-Record for publication.

"Watershed management in the snow zone of California" by H. W. Anderson. Describes cooperative snow management research with State of Calif. Dept. of Water Resources. To appear in the Trans. First Intersociety Conf. on Irrigated Agric. and Drainage, 1957.

## New Manuscripts

"Sulfur dioxide as a defoliant of chaparral species" by J. H. Patric. An effective method is described for causing defoliation of chaparral plants using liquid sulfur dioxide. To be submitted as Journal of Forestry note.

"Plan for treatment of vegetation to increase water yield--Big Dalton Canyon, San Dimas Experimental Forest" by P. B. Rowe. To be published as a Station Technical Paper.

"Water use by brush, grass, and grass-forb vegetation" by P. B. Rowe, L. F. Reimann, and R. A. Merriam. To be published as a Station Technical Paper.

"Some applications of watershed management research to foothill lands of central and southern California" by P. B. Rowe. To be published as a Station Misc. Paper.

"Improving determination of rainfall rates in mountain watersheds" by Everett L. Hamilton. Paper to be presented to the American Meteorological Society session at the Logan, Utah meeting of the American Association for the Advancement of Science, June 1958.

"Simplified method of sampling rainfall on the San Dimas Experimental Forest" by Everett L. Hamilton and Lyle F. Reimann. To be published as Station Research Note.

"Four hundred fifty storms--twenty-four years of rainfall data from the San Dimas Experimental Forest" by Everett L. Hamilton and Lyle F. Reimann. To be published as a Station Technical Paper.

"Evaporation data at elevations of 1500-5100 feet on the San Dimas Experimental Forest" by Everett L. Hamilton and Lyle F. Reimann. To be published as a Station Technical Paper.

"A field guide for rainfall measurement in mountain watersheds" by Everett L. Hamilton. To be published as Station Research Note.

"Dry-wet erosion in southern California mountains" by H. W. Anderson, G. B. Coleman, and P. J. Zinke. To be published as Station Technical Paper.

"Forest shade related to snow accumulation" by H. W. Anderson, R. M. Rice and A. J. West. To be published as a Station Research Note.

"Selection of best snow course points" by Arnold Court. To be published as a Station Research Note.

"Progress in snow management research in California" by H. W. Anderson. To be published as a Station Misc. Paper.

"Forest effects on floods in the Northwest" by H. W. Anderson and R. L. Hobba. To be published in Trans. Amer. Geophys. Union.

"Rain-snow flood sources, meteorologically defined" by H. W. Anderson; To be published as a Station Technical Paper.

"Penetration of radiation into snow" by K. J. Walsh. To be published as a Station Research Note.

## CURRENT RESEARCH

### San Dimas Experimental Forest

#### Watershed Management Tests to Increase Water Yield

Tests of applied watershed management described in the last semiannual report are now being carried out in the Big Dalton Canyon drainage of the San Dimas Experimental Forest. This work has been made possible by the cooperation of the California Division of Forestry, the Angeles National Forest and the Los Angeles County Fire Department. Trees and large shrubs in the woodland-riparian zone of Monroe Canyon are being removed and the stumps and residual vegetation deadened by an application of 2-4, D and 2, 4, 5-T. In nearby Bell Canyon Watershed #2 chaparral and forbs on selected side slopes will be helicopter sprayed with the same chemicals during the month of April.

Records of rainfall and streamflow over the past 20 years are available for the Bell and Monroe Canyon watersheds. In addition, records of sedimentation are available for the Bell small watersheds. These records, supplemented by measurments of current rainfall, streamflow, soil moisture, and evaporative losses in the treated and control watersheds will serve as a basis for evaluating the results.

#### Soil Sterilant Tests

Observations continue on the CMU pilot test plots laid out in August 1957 as noted in the last semiannual report. To date there have been no apparent differences in responses of vegetation to "Karmex W" applications of 10, 25, and 40 pounds per acre. Sensitive species are dead or dying on all plots, while seemingly immune plants continue to thrive.

#### Record on Collection Reduced

Emphasis on the new Big Dalton water yield studies has required a reduction in record collection in the San Dimas watersheds. Storage gages have been installed at high elevation rain gage locations. Separation of periodic rainfall into storm amounts for these gages is made on the basis of one Fergusson

recording gage equipped with a monthly clock. This gage is located at an elevation of 5,200 feet in Fern small watershed No. 2. The storage gage network in the Fern small watersheds has been discontinued and peak streamflow indicators have replaced the chart records from these watersheds. However, continuous records of streamflow from intermediate watersheds, I, II, and III in the San Dimas drainage are being maintained as before.

## Snow Studies

In our race with winter to install the other 2 dams in Onion Creek, we won a split decision -- we got one dam in and a concrete section poured at the other site.

The "heat equivalent and snow-study" was going nicely with measurements taken monthly at 63 courses, 24 points per course -- that is, it was going nicely until snow covered the 16-foot snow stakes during the storm of March 31. Fortunately, Al West had prepared detailed maps of every course so he will be able to continue sampling. Lost snow stakes plagued the Swain Mountain area, too, requiring re-measuring before making the April 1 survey.

The use of thermofax paper as an integrating radiometer hasn't passed the test yet. Ray Rice suspects that long periods of low intensity radiation do not give the same response as short periods of high intensity. We are next going to try adapting the Goodell Trystron tube radiometer to record on tally counters.

Our data processing punchout system is still being assembled. The first unit will be portable so it can be used in the field. The system is described in Study Plan 1.14 which has been sent to all stations.

## MEETINGS

October 8.--The Snow Hydrology group hosted a conference in Berkeley attended by 15 representatives of federal and state agencies interested in snow.

December 27.--The San Dimas Advisory Committee met to discuss the proposed plan for treatment of vegetation to increase water yield from Bell and Monroe watersheds on the San Dimas Forest. Eight members or representatives were present.

January 2.--Rowe talked to the Glendora Historical Society on "Mountain watersheds in relation to local water supply, floods, and erosion".

January 14-15.--The snow research team attended the California Snow Survey Conference in Quincy. Anderson outlined progress in snow management research. Next day, we hosted at the Central Sierra Snow Lab representatives of 40 agencies making snow surveys. Hopkins, Knoerr, Walsh, West and Rice described various phases of our research on the ground.

February 7.--Merriam presented a paper "Fire and streamflow in small woodland-grass watersheds" at the annual meeting of the Pacific Southwest Section of the American Geophysical Union at Pasadena. One of the field trips following the meeting was made to the San Dimas Forest on February 8. Rowe, Merriam, and Sinclair conducted a group of 10 members on this tour.

February 7-8.--Redding Research Review. Hopkins and Anderson presented papers on watershed management in relation to brushland and timber management. 170 attended.

March 24-25.--Director Arnold, Hopkins, Anderson, Rowe and Sinclair took part in a conference with Professors Hagan, Burgy, Myler and Zinke of the University of California, at the California Agricultural Experiment Station at Hopland, and discussed treatment and management of the University of California watersheds and grass interception.

## VISITORS

The San Dimas Forest was visited by 165 people during the last 6 months. Included were 80 students in 5 college classes, and 8 technicians from Argentina, Belgian Congo, Hawaii, Israel, Kenya, and Switzerland.

The Central Sierra Snow Lab was visited by M. J. Shelton, Deputy Director of the State Department of Water Resources, and Clair Hill, Chairman of the State Water Resources Board. They requested that we submit a comprehensive plan for Watershed Management Research in the State of California.

SEMIANNUAL REPORT OF WATERSHED MANAGEMENT RESEARCH

CENTRAL STATES FOREST EXPERIMENT STATION

October 1, 1957 - March 31, 1958

Athens Research Center

by: W. Carmean

## General

Major emphasis has been placed on the analysis of litter, soil moisture, and surface water runoff data.

## A. Effects of converting ridge sites to pine on the Vinton Furnace Experimental Forest.

### Litter

In the fall of 1953, 3 blocks were clearcut and planted the following spring. Litter samples have been collected in late summer during 1954, 1955, and 1957. Samples were taken of the litter (L) fermentation (F), and humus (H) layers of undisturbed oak forest and from areas that had been clearcut and planted to pine. Half of the clearcut area had been treated with herbicide to release planted pine and half of the clearcut area was untreated. Results of the litter studies are shown in figure 1.

These results indicate that clearcutting has not resulted in any important reduction of organic layers and that the soil surface is still adequately protected from raindrop erosion. Slash from logging and the rapid development of herbaceous cover, tree seedlings, and sprouts apparently furnishes adequate protection of soil in these clearcut areas.

### Surface Water Runoff From Small Plots

Preliminary results of the regression analysis of runoff from clearcut areas was described in the April-September, 1957, semiannual report. These results show that runoff from clearcut areas is related to the amount and intensity of precipitation and to the time since last precipitation.

Since the last report analysis of the runoff from the undisturbed oak forest has been completed. This analysis shows that on the undisturbed forest runoff is closely related not only to the amount and intensity of precipitation and the time since last precipitation but also to soil moisture content and time of year.

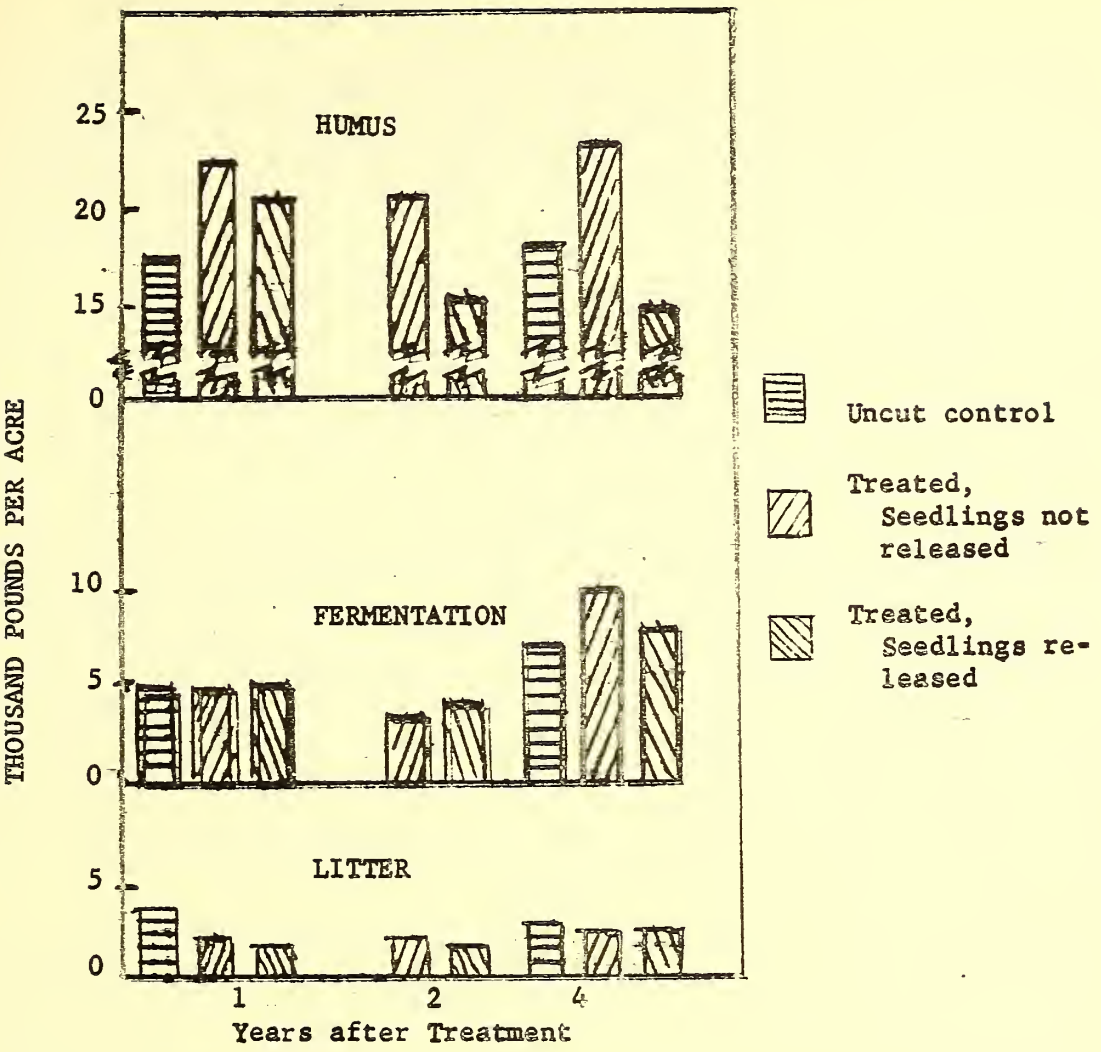



Fig. 1 - Effects on forest floor when converting oak-hickory ridge sites to pine

Soil Moisture

Analysis of soil moisture differences between clearcut and undisturbed plots is being made and graphs have been prepared showing soil moisture changes for the entire profile and for individual soil horizons.

A manuscript summarizing the above results on litter, runoff, and soil moisture is now being prepared.

B. Soil moisture levels for common vegetal cover types in southeastern Ohio.

This study consisted of weekly gravimetric sampling of soil moisture for

(1) undisturbed oak; (2) undisturbed natural shortleaf pine; (3) clearcut pine; (4) broomsedge; and (5) brush. Sampling was begun in March, 1956 and was terminated in January, 1958. Each plot has been sampled for bulk density and analyses have been made of texture, moisture equivalent, and 15 atmosphere soil moisture content. Data have been assembled and are now ready for calculation.

## Coshocton Hydrologic Laboratory

by: L. W. Hill

The effect on stream flow by changing forest type of vegetation--grass to trees.

Watershed 172 is a 44 acre watershed at the Soil and Water Conservation Research Center, Coshocton. For several years prior to installing the gaging station two-thirds of the watershed was a stand of grass and brush with one-third of the area a stand of uneven aged hardwoods. The non-forested portion was planted in 1938 with white, red and pitch pine. All storms recorded from June 1, 1939 to May 31, 1957 at the stream gaging station have been cataloged. An occurrence of 1/100 or more or precipitation separated by at least six hours of no precipitation was considered an independent storm. About 80 percent of the 1,236 unit storms had maximum discharges of less than 9 c.s.m.(Table 1). Results of this tabulation show that May, June and July are the months most likely to have maximum storm flows on tributary streams in eastern Ohio.

Table 2 lists the number of storm rises at the gaging station which have taken place in three periods. In period 1, 27% of the maximum discharges were from flows of 10 c.s.m. or greater. Period 3, however, had only one-half of this or 14 percent. The fact that storms for each period have become successively less suggests that the plantation is having an influence on maximum storm flows.

Inventory of the forest stand on four of the five forested watersheds at Coshocton was completed this winter.

Table 1 - Maximum storm flows: Watershed 172, Coshocton, Ohio
(Period June 1, 1939 - May 31, 1957)

| Month | Storm class (c.s.m.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-9 | 10-19 | 20-39 | 40-59 | 60-79 | 80-99 | 100-199 | 200-299 | 300+ | Total | Avg Per Mo. |
| Jan | 52 | 6 | 8 | 4 | 1 | 0 | 2 | 0 | 0 | 73 | 4.1 |
| Feb | 58 | 9 | 8 | 3 | 1 | 0 | 0 | 1 | 0 | 80 | 4.4 |
| Mar | 85 | 6 | 19 | 8 | 3 | 1 | 1 | 0 | 1 | 124 | 6.9 |
| Apr | 109 | 21 | 12 | 2 | 1 | 2 | 1 | 0 | 0 | 148 | 8.2 |
| May | 104 | 16 | 15 | 3 | 2 | 1 | 3 | 2 | 1 | 147 | 8.2 |
| Jun | 110 | 13 | 7 | 3 | 3 | 1 | 3 | 1 | 2 | 143 | 7.9 |
| Jul | 114 | 5 | 6 | 1 | 2 | 0 | 1 | 3 | 1 | 133 | 7.4 |
| Aug | 67 | 2 | 2 | 0 | 2 | 1 | 2 | 0 | 0 | 76 | 4.2 |
| Sep | 66 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 68 | 3.8 |
| Oct | 81 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 83 | 4.6 |
| Nov | 81 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 86 | 4.8 |
| Dec | 56 | 9 | 8 | 2 | 0 | 0 | 0 | 0 | 0 | 75 | 4.2 |
| Total | 983 | 90 | 87 | 28 | 15 | 6 | 13 | 8 | 6 | 1236 | --- |
| Avg. Per Yr. | 54.6 | 5.0 | 4.9 | 1.6 | 0.8 | 0.3 | 0.7 | 0.5 | 0.3 | -- | 68.7 |

Table 2 - Occurrence of maximum storm flows by storm classes for three periods of plantation development. Watershed 172, Coshocton, Ohio

| Period | Plantation Age (Years) | Storm class (c.s.m.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total | 0-9 | 10-19 | 20-39 | 40-59 | 60-79 | 80-99 | 100-199 | 200-299 | 300+ |
| I | 2-5 | 362 | 264 | 35 | 29 | 6 | 8 | 4 | 7 | 5 | 4 |
| II | 10-14 | 279 | 218 | 23 | 24 | 10 | 0 | 0 | 2 | 1 | 1 |
| III | 13-17 | 190 | 164 | 11 | 8 | 4 | 0 | 1 | 2 | 0 | 0 |

## Berea Research Center

### Strip mine study on Cumberland National Forest

The 4 man crew that started drift mining last fall continued to operate most of the winter. The study is now measuring effect of a drift mine instead of its original objective "to determine what quantitative changes will be produced by the introduction of strip mining in a watershed". For the three years of this study a major treatment change has occurred each year. This points up some of the problems in conducting a study on private land when there is no control over the study area or treatment. An in service meeting regarding the future of this administrative study was held at Winchester, Kentucky, on March 13. It was agreed we will continue the present measurements until the 4th meeting of the Work Survey Committee in June. At that time several changes in the study are to be recommended.

## Columbia Research Center

### Hydrology of small drainages

Whipkey has completed analysis of data for the "Hydrology of Small Drainages" study and has submitted a first draft of a thesis based on that study to the University of Missouri.

The April - September 1957 Semiannual report describes basin characteristics and land use for Green Acre Branch watershed near Rolla, Missouri, and reported on precipitation and runoff.

Additional analysis this winter consisted of making a list of all storm flows from the streamflow recorder charts. The 22 storms recorded at the gaging station in an average year is a sharp contrast to Coshocton with 68 and Coweeta with 128. The period May, June, July gave the largest number of storms and highest storm flows, and the period September - December the lowest number of storms and smaller storm peak discharge.

Table 3. - Maximum storm flows Green Acre Branch near Rolla, Missouri (Period Oct. 1, 1948 - September 30, 1955)

| Month | Storm class (c.s.m.) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0-9 | 10-19 | 20-39 | 40-59 | 60-79 | 80-99 | 100-199 | 200-299 | 300-500 | 500+ | Total | Avg. Per Month |
| Jan | 3 | 1 | 1 | 3 | 1 | 3 | 2 | 1 | 1 | 0 | 16 | 2.3 |
| Feb | 0 | 0 | 4 | 4 | 4 | 2 | 1 | 0 | 0 | 0 | 15 | 2.2 |
| Mar | 3 | 1 | 2 | 3 | 3 | 0 | 1 | 1 | 0 | 0 | 14 | 2.0 |
| Apr | 1 | 0 | 2 | 0 | 3 | 0 | 1 | 0 | 0 | 1 | 8 | 1.1 |
| May | 4 | 1 | 1 | 1 | 3 | 1 | 5 | 2 | 0 | 2 | 20 | 2.9 |
| Jun | 0 | 3 | 5 | 3 | 1 | 1 | 3 | 0 | 1 | 3 | 20 | 2.9 |
| Jul | 3 | 0 | 1 | 4 | 3 | 1 | 0 | 3 | 1 | 0 | 16 | 2.3 |
| Aug | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 1 | 0 | 0 | 15 | 2.1 |
| Sep | 0 | 1 | 0 | 2 | 2 | 0 | 2 | 1 | 0 | 0 | 8 | 1.1 |
| Oct | 2 | 0 | 1 | 3 | 2 | 0 | 2 | 1 | 0 | 0 | 11 | 1.6 |
| Nov | 4 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 8 | 1.1 |
| Dec | 2 | 0 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 7 | 1.0 |
| Total | 25 | 9 | 24 | 27 | 24 | 11 | 19 | 10 | 3 | 6 | 158 | -- |
| Avg. Per Yr. | 3.6 | 1.3 | 3.4 | 3.9 | 3.4 | 1.6 | 2.7 | 1.4 | 0.4 | 0.9 | -- | 22.6 |

### Cooperation - Soil Department, Missouri

### Rocky soils in the Missouri Ozarks

George Carter, a graduate soils student working under a cooperative-aid project, is currently compiling and analyzing soils data secured from a one-tenth acre plot

on the Sinkin Experimental Forest. The general soils series being studied is the Clarksville stony loam.

Carter used 16 holes, 12 inches in diameter, and 8 holes, 6 inches in diameter to test the variabilities within the plot. Weights and volumes of soil, rock and gravel were sampled from 0-10 inches, 10-20 inches, and 20-30 inches depths in each hole.

Specific gravities, bulk densities and moisture contents are being computed for the various profiles. Wilting co-efficients (15 atmospheres) were determined by the "Pressure Membrane" technique. One-third atmosphere values were obtained with the "[illegible] ration porosity" technique and "Field Capacities" were obtained by the "Cadbal" technique. Field capacity and 1/3 atmospheres values secured by these two methods are to be compared.

No quantitative values have been made available to the Center as yet, but there are indications of the following:

(1) In the top 30 inches of soil within a one-tenth acre plot, there is an extreme variability in soil, rock, and gravel content.

(2) Within the soils in the one-tenth acre plot, there are extreme variations in texture, volume weight and moisture holding capacity.

(3) Rock (mostly chert) may hold 2% or less water by weight at saturation.

(4) Gravel (chert and sand rock) may hold 5% or less water by weight at saturation.

## MEETINGS AND TALKS

Nov. 15 Johnson discussed watershed management research on forest land at the Columbus U. S. D. A. Club.

Nov. 19 Carmean attended the annual meeting of the soil Science Society of America held in Atlanta, Georgia. He presented a paper "The role of environment and tree physiology in determining site quality for forest trees."

Dec. 5 R-9 conference on how watershed management research may provide additional help to Regional personnel engaged in PL 566 projects. Attending the meeting were: Murphy and Frank, W. O., Weitzman, CS and McGinnies and Johnson, CS.

Jan. 27 Johnson talked to the Rotary Club at Portsmouth, Ohio, on forest watershed research needs for southern Ohio.

Jan. 29-30 Johnson attended the annual meeting of R-9 State and private Forestry Division and State Foresters held in Milwaukee, Wisconsin. He presented a talk on "The Midwestern Forester and His Watersheds."

Feb. 3-4 Johnson attended the meeting for creation of a National Center for the Coordination of Scientific and Technical Information, Western Reserve University, Cleveland, Ohio.

Feb. 13 Carmean and Johnson attended Society of American Foresters, Ohio Chapter Meeting, Columbus, Ohio.

Feb. 21 Johnson spoke at a seminar at the Department of Forestry, Iowa State College, Ames. His subject was "The Ames Forester and His Watersheds."

Mar. 3-7 Johnson attended the R-7 Supervisors Meeting, Upper Darby, Pa.

Mar. 24-28 Station-Research Center Leaders Meeting, Columbus, Ohio

## Publications

New Manuscripts

| | |
|---|---|
| Johnson, E. A. and Schwab, G. O. | The Role of the Land On Ohio's Water Resource. For: Ohio Mid-Century Governor's Conference on Natural Resources |

Instrumentation - Water Quality, Chemical

For the Beaver Creek strip mine study near Cumberland Falls, Kentucky, chemical water quality analysis is under direction of the U. S. G. S. Regional Water Quality Laboratory at Columbus, Ohio. When the project started water samples were collected at weekly intervals. Analysis of these samples showed p.H. values between 2.6 - 6.8 and the sulfate concentration from 6 to 1200 p.p.m. A need developed for information on the load of the pollutants. The weekly samples did not give a total load value. Tests were made using a specific conductance recorder. Readings around 40 micromhos were obtained from samples in non-storm periods to 3000 micromhos in storm periods. When specific conductance was compared to sulfate concentration, p.H. value, and dissolved solids, consistent ratios were obtained. A continuous conductivity recorder was installed at the Beaver Creek Gaging Station in 1957. From this record and the water discharge record a computation of the total sulfate and dissolved solid load are being made. Also the fluctuation of the p.H. values are being followed closely

There is a report on the "Study of the Field Performance of a Continuous Conductivity Recorder (Denver Research Project (1 A1)2"by John D. Weeks, Quality of Water Branch, Colorado, Sept. 1957. When certain watershed studies may influence dissolved solids, p.H. and sulfate ions here is a commercially available instrument that has been subjected to laboratory and field tests. For more detailed information we recommend as one contact, Mr. G. W. Whetstone, Ohio Basin Water Quality Laboratory, U.S.G.S. 2822 E. Main St, Columbus, Ohio.

SEMIANNUAL REPORT ON WATERSHED MANAGEMENT RESEARCH
Intermountain Forest and Range Experiment Station
October 1957 - March 1958

## GENERAL

George W. Craddock, Chief of the Division for many years, became Chief of the newly organized Division of Station Management on December 1, 1957. Otis L. Copeland, Jr. was designated Acting Chief of the Division of Watershed Management Research following Craddock's new assignment.

Richard B. Marston completed residence requirements for the Ph.D. Degree at Utah State University in March.

Copeland was designated by the Chief's Office last November as Forest Service representative to the Western Regional Project W-32 Technical Committee. This project is entitled "Basic Hydrologic Factors in Precipitation Disposal Related to Water Conservation," and has the following objectives:

1. To study the interrelationship of micro-meteorological and soil factors as affecting evaporation from soil surfaces.

2. To develop instrumentation for basic hydrologic measurements related to soil and water conservation.

3. To study the factors influencing disposition of precipitation with regard to surface runoff and the regime of that entering the soil.

4. To study the effects of vegetation management on the amount of moisture storage and utilizable runoff.

The Committee meets annually to hear reports of progress, to allocate project funds, and to review plans for future work. The last meeting was held in Tuscon, Arizona, December 3-6, 1957. Because this was the first meeting of this Committee with Forest Service representation, Copeland presented a brief discussion of watershed management research underway in the four western Stations and summarized the current studies by line projects. Further details concerning Regional Project W-32 can be obtained on request to this Station.

Prospects for a plentiful water supply this year along the Wasatch front are excellent. Measurements of snowpacks indicate water contents of from 20 to 40 percent above normal. On the Davis County Experimental Watershed snow depths of 127 inches were recorded the latter part of March; the Great Basin Research Center reported depths of 117 inches. And on March 31, it is still snowing!!

Publications

Root and soil relationships associated with the pole blight disease of western white pine. Charles D. Leaphart and Otis L. Copeland, Jr. Soil Sci. Soc. Amer. Proc. 1957. 21:551-554.

Soil management for forest trees. Frank W. Woods, Otis L. Copeland, Jr., and Carl E. Ostrom. USDA 1957 Yearbook of Agriculture. pp. 710-715.

Manuscript

Soil-site index studies of western white pine in the northern Rocky Mountain Region. Otis L. Copeland, Jr. Soil Sci. Soc. Amer. Proc. 1958. (accepted)

## BOISE RESEARCH CENTER

All WMR studies were continued during the fall and winter on a maintenance basis. Observations and field data collected during the summer are being analyzed. All study plans have been revised or modernized to conform with current procedures and objectives.

Logging Road Reseeding Study

Field data on methods of seedbed treatment on establishment of perennial grass cover on two logging roads retired from use were gathered last summer and analyzed during the winter. Conclusions reached from these analyses follow:

1. Mechanical treatments (scarification or harrowing) showed no significant improvement in the establishment of good grass cover over the standard practice of broadcast seeding.

2. A significant variation in plant cover establishment in relation to aspect was found. This was not unexpected, but it is of doubtful importance because logging roads are located on most all aspects in timber sale areas.

3. Woodchip mulching inhibited plant cover establishment. The inhibiting effect was not offset by fertilization of the mulched plots.

4. Fertilization at the rate of 200 pounds of a 20-20-0 mixture per acre had no significant beneficial effect on plant establishment.

## GREAT BASIN RESEARCH CENTER

Most of the watershed management research efforts during the past 6 months consisted of gathering routine climatic records and the preparation or revision of study plans.

### Snow control

In the Great Basin, like much of the western United States, most of the water supply is derived from snowmelt. However, by midsummer when water requirements are greatest, most of the streamflow from this source is exhausted, and a water shortage usually develops. If streamflow can be delayed by prolonging the snowmelt period through snow control, more water may be made available at critical periods. In the Great Basin, the use of barriers to induce snowdrifting, thus delaying melt, appears promising. A study is being started at this Center to investigate and evaluate the effects of induced snowdrifting on streamflow. One fence, 16 feet high and 60 feet long, was constructed prior to the beginning of the past winter. Additional fences, varying in height, length, and orientation are planned for next year. When optimum fence dimensions have been determined, fences will be constructed on a small watershed to test their effectiveness in drifting snow and its effect on streamflow.

### Equipment Design

A short duration study to design equipment for determining free water accumulation under snow in the springtime is underway. Past observations indicate that snowmelt water sometimes accumulates under the snowpack to depths of 1- to 3-inches. It is believed that this ponded water may damage germinating seeds as well as established seedlings. This work is being done in cooperation with the ARS.

## MISSOULA RESEARCH CENTER

Timber harvesting in the forests of Region 1 has nearly doubled in the past several years. On national forests, alone, the annual cut has increased from about 0.5 billion to nearly 1.0 billion board feet. This increase in cutting, with its attendant road building, is extending use to terrain generally rougher than that formerly logged. The increased area of operations and more difficult access into rough topography combine to present a potentially serious watershed maintenance problem.

Any logging on these steep forest lands creates watershed disturbance. Whether or not the disturbance is damaging depends upon how it affects the water control and soil stability characteristics of the land. During the past 10 to 15 years increasing attention has

been given to the importance of the road layout for access and logging; to standards for road construction; and to corrective measures for controlling water and soil on national forest timber sale areas. Emphasis on these matters has varied with time and place. In general, however, it has resulted in a tendency to build roads to higher standards and to install such corrective measures as cross-ditches on roads to divert water, water bars on skidtrails to prevent water accumulation, piling slash in skidtrails to slow the velocity of running water, and reseeding to improve plant cover conditions.

Although these measures have been applied in the interests of better watershed management, some have been inadequate for the purpose. Better information is needed concerning the effects of different road systems, of roads of varying standards of construction, and of corrective measures on roads and skidtrails in relation to the acceptable control of runoff and sediment production.

Insufficient studies have been made to obtain the information necessary from which to develop criteria required for acceptable watershed maintenance on timber sale areas.

In an effort to develop such criteria or guides for management, a decision has recently been made to direct the major part of the WMR effort for the next year toward a series of studies on road development and modified logging practices. This initial study is now being designed to evaluate the effects of past practices in road location and construction and maintenance on erosion and sediment production. It will cover seven of the more extensive forest soil groups in Region 1 during the coming summer season.

Manuscripts

Two manuscripts were prepared for publication during this period by Paul E. Packer. "A proposed watershed management research program on forest and rangelands of the Upper Columbia and Missouri River Basins," recommended for a Station Miscellaneous Publication, and "Management of forest watersheds and improvement of fish habitat," submitted to the Transactions of the American Fisheries Society.

## NEVADA RESEARCH CENTER

Problem Analysis Continued

In the past six months, more progress has been made in developing a detailed analysis of the watershed management research needs in the Truckee River Basin. Although many of the details have not been explored yet, we are reasonably certain that the analysis will probably point to three major problems: the reduction of winter rain-on-snow

(wet mantle) flood volumes, peak flows and damages from sedimentation; the prevention of high-intensity rain (dry mantle) floods; and the improvement of water yield.

Center Office to be Moved again in Reno

After a pleasant but short stay in our remodeled offices, the Center will vacate and loan the building to the expanding Toiyabe National Forest headquarters. This has been made possible by an offer from the University of Nevada to occupy a suite of offices and a small laboratory in their new Max C. Fleischmann College of Agriculture building. We have accepted this offer and hope to accomplish the move by the end of the fiscal year.

Meetings Attended

October 3-4: Craddock, Hopkins (California Station), and Haupt attended the 11th Annual Nevada Water Conference at Carson City, Nev. Craddock presented a paper on the progress of watershed management research in the Intermountain Region.

December 4: E. S. Kotok, Forest Utilization Research, and Haupt discussed FUR and WMR needs with the Lincoln County Rural Development Committee at Caliente, Nevada.

February 20-21: R. C. Holmgren, Range Management Research, and Haupt attended the Soil Conservation Service-sponsored Soil and Water Research Needs conference in Reno.

## WASATCH RESEARCH CENTER

Parrish Streamgaging Station

The new 120° V-notch weir installed at the mouth of Parrish Creek is now in operation. A measure of the volume of the weir pond was obtained by marking the height of the cutoff wall at 6-inch intervals, and determining the time required for the water to rise in the pond to each successive mark. The head rose to 0.33 feet over the weir after the pond filled. Theoretical flow for this head is 0.2933 c.f.s. Volume of the pond, 30 feet long, was calculated to be 3555 cubic feet by using the 0.2933 c.f.s. rate of flow and the filling period time. Pond volume will be rechecked by means of a cross-section survey, and the theoretical discharge of the weir will be checked by current meter measurements.

Water Use by Aspen and Mountain Brush Vegetation

This is the new study in which the neutron meter will be used to determine soil moisture. Duplicate, 6-foot 8-inch long, access pipes for the neutron probe were installed in the uphill corners of twelve pits in each of the two vegetal types. Installation of the 48 pipes was completed just before the winter snow commenced. They protrude only 8 inches above the ground surface and were covered with loose fitting improvised caps. All installations have been covered with varying depths of snow throughout the winter up to a maximum of 10 feet. No neutron meter readings have yet been made for soil moisture content, but the first ones are scheduled for the period just prior to snow disappearance.

Two sets of soil samples were taken, in duplicate, for each foot of profile depth in each pit: one consisted of small undisturbed cores; the second set were large, loose samples chipped from the walls of the pits. Bulk density of the small samples increased with depth to about 4 feet, and remained about the same or decreased slightly at lower depths, varying from 0.60 for a sample at 6 inches below the surface to 1.92 for a sample at 66 inches below the surface.

Average water content of the mantle to a depth of six feet at the end of the 1957 growing season was 8.07 inches in the aspen and 6.56 inches in brush. Average precipitation was assumed to be the same in brush as in aspen. On this assumption, brush vegetation used 1½ inches more water in 1957 than aspen. This is difficult to explain, in view of the fact that the density of the aspen exceeded that of the brush. No records were obtained for vegetation on a volume basis to permit quantitative comparisons. Results from this one summer's work must be supplemented with additional years of records.

Supplemental bulk density measurements were made on the large, loose samples as they were collected. Laboratory treatments of the loose samples include: determining oven-dry weights; sieving to ascertain the proportion of rock fragments greater than 2 mm in diameter; and measuring moisture contents at 1/3- and 15-atmospheres pressure. The profile of each pit was described and recorded. Collectively, the more obvious features of these 24 pits were the large volumes of stone and the absence of a well-developed B horizon.

Parrish Runoff Plots

Studies of relationships between plant cover, precipitation, overland flow, and sediment eroded from plots in the head of Parrish Canyon continue to require much time and effort.

One interesting phase observed by many people, but which has not yet been thoroughly investigated, is the ecological responses of the

vegetation to the various treatments imposed. In the past, primary interest in the treatments was their effect upon overland flow and erosion. Observations made did not suffice to show the detailed ecological changes that have occurred. More intense ecological observations might reveal some of the reasons for certain results obtained to date.

Six, 1/40-acre plots (nos. 1-6) were established in 1936 on a depleted flood-source site. Under protection from fire and grazing, an aspen-herbaceous cover established itself quickly on 2 plots. Two other plots revegetated more slowly, while on the last two only herbaceous cover re-established itself. In 1947, one of the plots that revegetated slowly (#5) and one that was covered with only herbaceous plants (#3), were bared and kept bared artificially. Aspen sprouts and seedlings from annual plants are removed from plot 5 each year, while clumps of a perennial grass, Stipa columbianna, and seedlings of annuals must be removed from plot 3. Why do these perennial plants exist under these conditions and what would be the ecological succession if vegetation were allowed to return on the bared plots?

Four, 1/10-acre plots (nos. 7-10), were established in 1936 on an aspen site with a depleted herbaceous understory. At that time, no signs of accelerated erosion or excessive storm runoff existed on these nonflood-source areas. Under 10 years of protection (1936-1945), the understory increased in density from less than 10 percent to more than 30 percent and the overstory increased from 6 to 11 percent.

In the spring of 1947 cover on two of these plots was altered. The aspen overstory of plot 8 was removed causing, of course, an immediate decrease in live plant density. During the following 4 years this decrease, due to the loss of the aspen overstory, was offset by an increase in herbaceous understory that continued until 1951, when the total density again became nearly the same as in 1945, before treatment. Since 1951 plant density has declined (table 1).

Table 1.--Ground cover, Parrish plot 8, 1936-1957.

| Year | Live vegetation percent | Total ground cover percent |
|---|---|---|
| 1936 | 7.66 | ___ 1/ |
| 1937 | 9.52 | ___ 1/ |
| 1945 | 32.28 | ___ 1/ |
| 1947 | Aspen removed | |
| 1948 | 19.49 | ___ 1/ |
| 1949 | 27.07 | 82.77 |
| 1951 | 32.81 | 74.35 |
| 1953 | 21.41 | 81.65 |
| 1955 | 23.35 | 69.80 |
| 1957 | 20.85 | 71.08 |

1/ Not determined

The area occupied by perennial plants has decreased and the number of annuals has increased. The ecology of this treatment needs to be followed closely because removal of aspen has been contemplated as a possible treatment for increasing water yields. Will removal of the shade of an aspen overstory result in an ecological change, from a shade-tolerant herbaceous understory thick enough to offer adequate overland flow protection, to a sun-loving herbaceous cover that is too thin, at least temporarily, for adequate protection?

In the spring of 1947, all vegetation and litter were removed from plot 7 by cutting, burning, and raking. The enormity of soil losses that occur when the protective cover of vegetation is removed is illustrated by records from plot 7. For 11 summers, 1936 through 1946, no soil was lost from this plot, even though it was subjected to intense summer rainstorms. Since treatment in 1947, about 1/4 more summer rainfall occurred than before, but there has been 68 times more overland flow, and the amount of sediment eroded which was 0 before denudation, now totals 2426.7 cubic feet per acre or 0.67 area-inches (table 2).

Table 2.--Summer precipitation, overland flow, and sediment eroded from 0.1 acre Parrish plot no. 7, 1936-1957.

| Period | Summer precipitation | | Overland flow | | Sediment eroded | | |
|---|---|---|---|---|---|---|---|
| | Storms | Depth | Storms | Amount | Storms | Amount | Depth |
| | (no.) | (in.) | (no.) | (cu/ft/A) | (no.) | (cu/ft/A) | (in.) |
| Before denudation(1936-46) | 130 | 34.08 | 23 | 242.7 | 0 | 0 | 0 |
| After denudation(1947-57) | 161 | 42.23 | 49 | 16554.9 | 34 | 2426.7 | 0.67 |
| Total | 291 | 76.31 | 72 | 16797.6 | 34 | 2426.7 | 0.67 |

Six other 1/40-acre plots were set out on a steeper, depleted brush site. The only treatment, to date, has been protection from fire and grazing. Density of live vegetation has increased under this protection, from an average of 8.1 percent in 1936 to 37.9 percent in 1957. Unfortunately, the role of litter was not considered in the early estimates of ground cover on these plots. But, since 1949, the inventories have included an approximation of the amount of ground covered by litter in addition to that covered by live vegetation. Previous analyses have shown that overland flow and sediment eroded are correlated with total ground cover, and that total cover must be near 65 percent in order to prevent excessive losses. It would be interesting to know the relative protective value of litter to live vegetation in this respect.

LAKE STATES FOREST EXPERIMENT STATION

# WATERSHED MANAGEMENT RESEARCH SEMIANNUAL PROGRESS REPORT
October 1, 1957 to March 31, 1958

## GENERAL

The past 6 months have been largely devoted to collection and analysis of data at the Headwaters Research Center (northern Minnesota) and Lower Peninsula Research Center (Lower Michigan). In the Driftless Area major effort was toward selection of potential experimental sites.

## PUBLICATIONS

Several articles were prepared. The following was published.

Stoeckeler, J. H., and Thames, John
The Lake States Penetrometer for Measuring Depth of Soil Freezing. Soil Sci. 85: 47-50, illus., January 1958.

## PROGRAM

The small watershed staff is operating without Stoeckeler who has been assigned for 6 months on a cooperative shelterbelt project with the Rocky Mountain Station.

## Headwaters Research Center

### Have snow tube, will sample

Nature has presented a problem in our research program concerning snow accumulation and melt -- almost no snow! A "typical" northwoods winter did not occur and even the snowbunnies on the ski slopes are having a difficult season.

However, the lack of an early winter snowpack resulted in deeper soil-frost penetration. A mid-February warm period, during which most of the meager snowpack melted, caused an interesting pattern of soil freezing. Under timber stands hard freezing penetrated over 10 inches by early February. This is deeper than observed last year. After the melt period in mid-February, cold temperatures resulted in concrete frost forming in the humus; probably because of its high moisture content. Concrete frost was also found in sandy soils where it had not been found the previous year, nor had it been observed prior to the period of thawing and freezing. It is theorized that this was caused by infiltration and percolation of snow-melt water which was later frozen by cold temperatures. Hard frozen humus and extensive soil freezing could have an important effect on runoff if late spring snowstorms or early rains occur.

## Soil moisture studies

Calculations on soil moisture data are now being completed and should be published within the next 6 months. In this study six cover conditions and a range of stocking levels within certain forest types were sampled for soil moisture throughout the summer. Several different soils were also represented. So far, a partial tabulation of the data indicates no significant trends, neither between forest types nor between stocking levels. After final analysis of the data we will know whether or not we can support Penman.

## The search is on -- for experimental areas

Northern Minnesota, with its vast acreage of spruce swamps and rolling uplands, is not the ideal region for locating small, sharply defined watersheds. We will be dealing with quite large areas with intermingled soils and forest types. Problems in structures and instrumentation should be quite interesting -- and challenging. We intend to begin ground water investigations this summer and plan to coordinate all this work on experimental watersheds.

## Manuscripts submitted

Cutting methods affect snow accumulation and melt in black spruce stands - Roger Bay

Conversion of forest type affects snowpack in northern Minnesota - Roger Bay

Occurrence and depth of frozen soil varies by forest type in northern Minnesota - Roger Bay

-- Roger Bay

# Lower Peninsula Forest Research Center

## Project analysis

A project analysis for the State of Michigan is rapidly nearing completion. Professor R. E. Dils of the University of Michigan has been actively engaged for the past 9 months on this task. (This analysis of Michigan's water problems should serve as a guide for planning future watershed management research.)

FS History Office
Reference Shelf

## Soil moisture

A work plan for a study of the soil moisture and ground water regimes under some of our major forest types has been completed and measurements have been started as of last fall. A series of replicated plots affording comparisons between forest types and between general soil texture classes has been established. Soil texture classes and forest types sampled include:

1. Sands - support red pine plantations and scrub oak.
2. Loamy sands - support red pine plantations and northern hardwoods.
3. Sandy loam over a clay - support pine plantation and northern hardwoods.
4. Clay - supports northern hardwoods.

An open plot is established in conjunction with each set of forested plots. Ground water wells have been established on several plots and more will be put in this summer.

The purpose of the study is to determine the effects of the various forest types upon the recharge and depletion of soil moisture and consequently upon the recharge and depletion of the ground water reservoir.

## Snow and frost

A work plan for a study of snow and frost under some major soil-vegetation associations of northern Michigan has also been completed and the first winter's observations almost completed. In this study we are utilizing the same plot establishment as in the soil moisture study, thus our snow and frost work is merely a continuation of our basic studies of the soil moisture and ground water regimes as affected by forest cover types.

The primary objectives of studying snow and frost are to determine the value of the snowpack as a source of soil moisture and ground water recharge and how it is modified by the vegetative cover. The variation of soil types sampled also gives us excellent opportunity to observe frost incidence by texture class.

Preliminary analysis of our snow and frost measurements shows them to be fairly consistent and reasonable. Deepest average snow accumulations were observed in young pine plantations in which the crowns have not yet closed, thus causing a drifting effect over the plot. Snow depths in open plots average slightly greater than oak or northern hardwood during the period of accumulation while lowest snow accumulations were recorded in closed-crown pine plantations. Water equivalents closely conformed to snow depths insofar as order of magnitude in between plot comparisons is concerned.

During the period of snowmelt the open plots naturally lost "the mostest the fastest". Snowmelt under the forested plots still continues at various rates with the final measurements still not completed. The big question is: Will the pine plots with a slower rate of melt, but less snow, outlast the oak and northern hardwood plots with their greater melt rate but more to be melted? At this date, the odds appear about even.

Frost results this winter are somewhat erratic. This is partially due to the comparatively mild winter and partially due to the fact that the small amounts of frost observed on most plots during the beginning measurements disappeared upon the arrival of a heavier cover of snow. Subsequent measurements may be summarized briefly--little or no frost was found under oak or northern hardwood forest types while up to 12 inches of hard frost were observed under pine plantations and open conditions. In several instances frost was found under pine plantations when none was found under open field conditions. Deepest frost measurements were found in sands and loamy sands while no frost was observed in the clay soil with the exception of the winter's first measurements.

"Dry-concrete" frost

This frost form, described in the last semiannual report, was observed in sandy soils during the winter's activities. "Dry-concrete" frost is apparently the result of the deep freezing of the capillary water in sandy soils, thus binding each partical into a hard contiguous mass, yet leaving the interstitial spaces relatively free and permeable. "Concrete" and "dry-concrete" frost were found forming a "frost profile" in this winter's observations. The upper 2 to 4 inches of frost in several plots were regularly found to consist of "concrete" frost, while the remaining 6 to 8 inches would be "dry-concrete". Lines of demarcation were generally discernable and probably indicate the depth to which melt waters were able to penetrate before refreezing occurred. Examination of moisture contents of the two types shows that "dry-concrete" frost is "dryer" by about 15 percent (by weight).

-- David Striffler

## Driftless Area

A 22-page report was prepared on potential experimental watershed areas in southwestern Wisconsin. This report was prepared for the Wisconsin Conservation Department who may acquire some of these for use of the Station. The work was greatly accelerated by use of air photos and U.S.G.S. quadrangle sheets which cover the entire area of 10 or more counties.

A progress report was prepared by Stoeckeler on the results of soil moisture samplings on transects from ridge to ridge across an east-west valley in the Driftless Area near La Crosse, Wis. The most striking thing was the much higher moisture content on the cool north-facing aspects compared with the hot, dry south-facing aspects. This helps explain the great difference in mean annual increment of the native timber on the two aspects.

-- J. H. Stoecekler

NORTHEASTERN FOREST EXPERIMENT STATION

Division of Watershed Management Research

Semi-annual Report April 1958

## GENERAL

The big picture this winter was pretty well obscured by snowfalls which were frequent and wet; one observer even reported snowflake-splash.

Between storms:

1. Norman Tripp and Howard Lull collaborated on two papers, one for the SAF meeting and one at the request of the New England Water Works Association.

2. A survey of municipal watersheds in the Northeast was completed: turned out there are about 400 with a forest area of about 1 million acres. A series of three papers on municipal forest watersheds was prepared for the Journal of the American Water Works Association.

3. A 30-page paper on forest management in a watershed management program was prepared as background material for an FAO handbook.

4. Si Little's Coastal Oak-Pine Research Center came up with a watershed research project--the City of Newark agreeing to establish 3 small experimental watersheds on the city-owned 30,000 acre Pequannock watershed.

## KINGSTON RESEARCH CENTER

### Leading Ridge Watershed

Road location and weir sites for watersheds 2 and 3 at State College, Pa. were selected and road construction will begin as soon as weather permits. This cooperative watershed management research project will be dedicated at the summer meeting of the Pennsylvania Forestry Association to be held at State College.

### Snow in the Poconos

When we began our watershed management research in the Poconos in 1948, we were informed that snow was an important climatic factor. Thus, a part of our research program was based on snow management--the possibilities of encouraging deeper accumulations and prolonging the melt period. This is the first year that snow cover was not intermittent or relatively unimportant. Perhaps such a snow accumulation occurs in 10-year cycles and the local folks just remembered the last heavy snow.

Snow depths at the Pocono Experimental Forest were up to 48 inches several times during the winter. The most recent measurement on April 9 showed an average water content of 10.69 inches for the snow course.

## Soil Moisture Study

Analysis of the data collected last summer at Dilldown has been completed. It indicates that there are significant differences in the amounts of water held in the soil during the growing season under different vegetative covers. A control plot, with a mixture of scrub oak and ground cover, consistently had the lowest soil moisture at all the depths sampled. A ground cover plot had the next lowest soil moisture. The difference between this plot and the preceding one, caused by scrub oak, was insignificant. Plots on which all the vegetation was deadened consistently showed the highest soil moisture. A scalped plot was extremely variable but generally maintained an intermediate position.

## Soil Survey

Plans are being made for a detailed soil survey of the Pocono Experimental Forest this summer. Cooperation has been promised by the local S.C.S. men, and a work plan is being prepared.

## Watershed Calibration

Reigner has been churning out numbers in order to have the finished product to present to the American Geophysical Union meeting early in May.

The last development was the production of a curve to adjust precipitation data by size of storm. Part of every storm leaves the watershed as storm runoff and has no effect on storage. This relationship is curvilinear, that is, a disproportionate amount of a large storm runs off directly. As an example, a 9 inch storm in July 1952 yielded 2.78 inches of storm runoff; but a 3 inch storm under the same antecedent conditions would yield only 0.30 inch of storm runoff.

As we are interested in storage estimates, our precipitation data had to be adjusted to allow for storm size.

## Miscellaneous

Reigner and Eschner with Lull and Storey paid a visit to the Baltimore city watersheds where a new cooperative watershed management study is being set up. Concrete block stilling basins are being constructed by the watershed supervisor.

## MOUNTAIN STATE RESEARCH CENTER

### Snow on the Fernow

This winter an unusually deep snow pack has blocked roads into the Fernow and the Clover Run watersheds for days on end. Making our weekly precipitation observations, and changing charts has necessitated snowshoeing long distances (and Ken Reinhart even tried out his skis--no comments!). It may be some consolation to the men at Hubbard Brook to know we have broken trail on snowshoes for 10 miles stretches this winter, changed charts at 11° F below, and chopped 4 to 6 inches of ice from around the weir blade. Highlight of this winter's misery was Reinhart's tumble into a four-foot deep weir basin on a zero degree day (after he chopped the ice out). Burley Fridley pulled him out, and he skied two miles down to the car in a suit of mail. Not so discriminating as Sid Weitzman who fell in Weir #2 (and had to be rescued against his will), Ken fell in one of the Clover Run weirs that runs just cheap, old, pure, pipe-rusting water.

### Soil Moisture Measurement

We hope to use our nuclear moisture meter (procured from Johnson and Associates), for soil moisture sampling this summer. There are many drawbacks to its use in the forest but the advantages of in situ volumetric measurements seemingly outweigh them. Driving the aluminum access tubes into the rocky Fernow soils is one of the main drawbacks. Another is the change in calibration during use, caused by battery drain. We hope to overcome this by obtaining a larger wet battery than we now use. Another problem is that the meter is heavy and bulky to carry up some of the steeper slopes.

### More Water Quality Data

In cooperation with the Bureau of Sport Fish and Wildlife, we are adapting our water quality measurements to determine effects of cutting practices upon fish habitat. In addition to measurements of turbidity, we are now determining pH, temperature, alkalinity, and total $CO_2$. pH may be a very important factor in fish environment.

Some preliminary results are already coming from our clear-cut watershed. Suspended sediments on the clear-cut range up to about 50,000 ppm; turbidities by ocular measurement run between 50 and 5000 units. This compares with suspended sediments of 10 ppm for the control watershed. We have finished bulldozing skid roads in the other 3 watersheds to be cut later. No logging has yet been done and the roads show no compaction or erosion. Turbidities of the runoff have not increased since road building; they still run under 5 units on the Jackson turbiditimeter. This picture may change when we get more rain.

## Surveys and Computations

Boundary surveys of the two new Wilson Hollow watersheds (forested) were recently completed. The acreages were 55.2 and 55.9. Surveying is about finished on the two abandoned-farmland watersheds on Clover Run.

Watershed computations on the five original watersheds are being kept as near up-to-date as possible in anticipation of the end of the first year of treatment on our clear-cut watershed--May 1. There are about five weeks of logging left to clearcut this watershed.

## Thanks, Fellows

The Northeastern Station, through the Washington office, recently requested from all Stations material on weir construction that would be helpful to Pierce and Reinhart for their proposed paper on the subject. The response was gratifying and we wish to express our thanks to all who responded. With this help, the authors hope to put out a paper which will be of value to those faced with weir construction problems.

# WHITE PINE-HARDWOOD RESEARCH CENTER

## Snow at Hubbard Brook

Weather has been very much in the news all over the East this year. In some parts of the White Mountains record snowpacks blanket the ground. Laconia has been buried under the deepest snow for some years. But, surprisingly, the snowpack on the Hubbard Brook Experimental Forest is no greater than it was two years ago; and that was not an unusual year. Our present water content is about 9 inches. Of course, it's snowing now (March 21) and spring could still be a month away in the hinterlands.

Our weasel--Cargo Carrier, Amphibious, M29C, by army jargon--arrived about three weeks ago from army surplus in California. Except for corrosion on some of the splash panels and a broken windshield, it is in excellent condition. We have used it already. We had no trouble climbing a 20 percent grade with about three feet of snow on the ground. It left a track impression about 5 inches deep. Beats snow shoeing any day!

## Integrated Plot Study

We are not entirely pleased with this title but for want of a better one it has stuck. As mentioned in a previous quarterly report this study is an intensive investigation of a large number of factors involved in the hydrologic cycle, e.g., soil moisture and temperature, weather, vegetative cover, etc. on three differently treated plots.

Sartz turned in a 48-page working plan on the frost and snow phases, the heaviest piece of work that has come off the Center's typewriters since Trimble had all hands knee-deep in his problem analysis. The plan describes

in detail how we will determine differences in the frost and snow patterns on three hardwood forest plots both before treatment and after cutting two of them by different methods. The study was actually started last fall. So we already have our first year's data.

As part of this integrated study we would also like to determine the effects of treatment on soil moisture. But in order to determine them we must first be able to measure soil moisture effectively. The techniques for doing this on our kind of soils do not exist at the moment. We will try to develop some this summer. As of now we lean heavily toward one of the neutron-scattering devices.

In the meantime, and also on the integrated plots, we are planning an interception study to give us a net rainfall figure for soil moisture analysis. Leonard is preparing the working plan. It calls for measurements of both throughfall and stemflow. While a good bit of interception work has been done through the years, many of the results are contradictory; and none of them could be applied directly to our plots.

Weirs, Road, and Laboratory

Weir No. 3, our latest, was set in operation at the beginning of the dormant season. The use of a removable trough which does not interfere with the free-fall of water below the notch has enabled us to obtain rather precise calibration curves.

Using the suggestion of the California Station we have placed peak-roof shaped hoods over the notches in hopes these will lessen the ice build-up at the blade during extreme cold temperatures. So far they seem to have helped but a modification in their design may be tried to increase their efficiency.

Bob Pierce and the engineering staff of the White Mountain National Forest are writing construction specifications for our next two weirs and will place these for bid by private contractors. If the bids are not exorbitant and a reliable and skilled contractor is secured, contracting the weirs should free our technical staff to undertake summer duties we normally have been unable to pursue.

Much to our pleasure the second section of road into the watershed is nearing completion. This next piece will extend the road to almost 4 miles--in close proximity to the main brook. From here on it looks like road construction may keep ahead of our weir developments.

Plans have been laid for a Soils and Biological Laboratory in the basement of the Forest Service Building in Laconia. The White Mountain National Forest has graciously given up approximately 870 square feet of their storage space to permit the establishment of this much-needed lab. If sufficient funds are available the space will be converted to a large general purpose laboratory for use in soils, pathology, and physiology investigations. A small portion of the space will be partitioned into 4 rooms for specialized activities.

## Compilation

We have finished revising our compilation procedures for climatic and streamflow data. Some of the old, standard precipitation and runoff forms were revised, and a few new ones added. The result is a simpler compiling system and a much smaller accumulation of paper per year. The new system has been written up and assembled as an instruction manual.

## Soil Moisture Measurement Discussion

We were very happy to see the discussions on soil moisture measuring by John Hewlett and the Piedmont Research Center (Lou Metz?) in the last semi-annual report. We are currently wrestling with the same problems, albeit only at the feet-on-desk stage thus far. If soil moisture sampling by the usual methods requires a close look in the residual soils of the South, it most certainly requires a closer one here in the mountains of New Hampshire.

Besides the usual roots, rodent burrows, and insect tunnels, we have crazy, mixed-up glacial till soils. We have all manner and sizes of sand, gravel, and boulders--alone or in mixture. We have 6 inches of humus and we have no humus--2 feet apart. We have buried profiles and we have humps and hollows--the result of windthrow through the years. This is the natural landscape. It is a soil sampler's nightmare.

So we still have our feet on our desks. We haven't yet given up the idea of using Colman units--if only to track soil moisture movement to various depths after various amounts of rain. We think, though, that a neutron scatterer or some similar device offers the only real solution. With our bouldery soils we would still have some problems. We would have to sample very intensively because of extreme variability. But once the tubes were in the ground we could get by with one small boy to carry the rig instead of our whole staff armed with sampling cans and driving hammers. And we would be getting useable data. As I see it, the only big problem would be to convince the natives that we are really not prospecting for uranium.

## PUBLICATIONS

Influence of land use on time of soil freezing and thawing in the Northeast. Richard S. Sartz. Jour. Forestry 55: 716-718. 1957.

What they said about forests and floods in Pennsylvania 50 to 75 years ago. Howard W. Lull. Pa. Forests 37: 91-92, 107. 1957.

Forest soil-moisture relations in the coastal plain sands of southern New Jersey. Howard W. Lull and John H. Axley. Forest Sci. 4: 2-19. 1958.

How type of soil frost affects infiltration. George R. Trimble, Jr., Richard S. Sartz, and Robert S. Pierce. Jour. Soil and Water Conserv. 13: 81-82. 1958.

Manuscripts submitted:

Forest and water management on reservoir properties and municipal watersheds in the Northeast. Howard W. Lull.

Municipal watersheds in the Northeast. Howard W. Lull.

Logging roads on municipal watersheds. G. R. Trimble, Jr.

Management problems and opportunities on forested watersheds in the Northeast. Norman R. Tripp and Howard W. Lull.

Forest watershed management in New England. Howard W. Lull and Norman R. Tripp.

PACIFIC NORTHWEST FOREST AND RANGE
EXPERIMENT STATION

Semi-annual Report
Watershed Management Research

October 1, 1957 - March 31, 1958

## General

### Cooperation

Cooperation of one kind or another has been a highlight of our activities during the last six months. Part of this effort has been devoted to the Alsea Basin Study under auspices of the State of Oregon Committee on Natural Resources. We have looked at watershed problems in the drainage, reviewed their plans for surveys and investigations and at their request made suggestions for new studies.

We were also invited by the State of Washington Department of Natural Resources to examine their plans for a large state-owned unit of virgin timber on the Olympic Peninsula. In developing this body of timberland they hope to learn more about watershed management and encourage watershed research by any outside agency able to undertake it. We examined their watershed problems, offered sympathy and advice but held out little hope for expansion of our research program in that area.

Cooperation with the City of Portland has been in effect for almost two years. This spring we reviewed our program with City officials and pointed out the need for doubling their financial support for the sake of efficiency and sustained production of results. No results yet but the prospects seem hopeful.

Not all our efforts are crowned with success. For some time we have tried to work out an agreement with a private lumber company which would enable us to set up a long-range watershed program in a drainage near Wenatchee. Alternate sections in company ownership, are located in such a way that access and control of operations on any one subdrainage is impossible without cooperation of the company. After several meetings "at the summit" negotiations were broken off when it became apparent that our arguments in favor of such cooperation were not meeting with success.

### Training

During fall and winter quarters, Wooldridge attended University of Washington, College of Forestry where he took additional work as a further step toward attainment of a Ph.D. degree.

Norm Miner has completed plans for additional graduate work, also at University of Washington. He will begin on his Ph.D. program next September.

Bethlahmy spent a week in March at the Region 6 Administrative Management School.

## WILLAMETTE RESEARCH CENTER

--- by Jack Rothacher

### General

In the last semi-annual report we mentioned the increased attention by the general public to water and watershed problems. Now we have the ultimate. The Willamette Valley Logging Congress spent one entire day of their two-day meeting discussing the problems of watershed management in relation to logging! There was a good attendance at the meeting, too.

The Oregon State Water Resources Committee held a hearing on the use of the waters of the Upper McKenzie River for power production. Objections by the recreationists did not seem as strong as they have been on similar projects proposed in the past. The Committee has not yet announced their decision. The most recent development is a request by the State Game Commission to delay action until they have had more time to study the problems.

### Watershed Studies (FS-1-w5-2; FS-1-w5-3; FS-1-w7-6)

Principal efforts have been directed toward completing the analysis of 5 complete years of streamflow records, and starting treatment by the construction of logging roads into experimental watershed #3.

Analysis of streamflow data from the experimental watersheds is progressing satisfactorily, and should be up to date in about one month. Analysis of the 1954 records of watershed #1 indicate that runoff amounted to 61 percent of the annual 92 inches of precipitation. Daily flows ranged from a high of approximately 80 csm to a low of .07 csm.

We are getting ready to build roads into watershed #3 to see what effect they will have on sedimentation. We tried to finance construction out of experimental forest road funds but our sights were a little high. For the kind of road needed in this country ($30,000-$50,000 per mile) we would have used the entire amount allotted nationally for experimental forest roads. Next best idea is to finance them from timber sales although our timing requirements introduce some features not commonly encountered in timber sale procedures.

We have laid out a sale for this purpose that includes some 4.3 miles of road and about 12-million board-feet of timber. Roads have been surveyed and the forest engineering staff will complete their design in another month. The sale includes a total of six cutting units lying both inside and out of the experimental watershed. Using the accelerated amortization policy now in force, we hope that the income from three units outside the experimental watershed will cover the cost of the entire road system. The sale will then be more attractive to potential buyers.

The three units inside the experimental watershed, cover about 25 percent of the drainage area and will not be cut until three winter seasons have elapsed after the completion of the road system. We estimate this will allow us sufficient time to study the changes caused by road construction alone. Following the three-year interval, logging of the three units inside the watershed will proceed, to give us a second phase of the study.

Landslides

The 1957-58 winter was one of the wettest and warmest on record. With two periods of exceptionally heavy rainfall in December, the total for the month was 31.97 inches and was the highest in six years of record. The first storm (5-1/2 inches) caused several slides, one in a logging unit cut over 6 years ago. It originated near the top of the unit, having no apparent connection with road construction or other improvements. It was relatively small, about 1100 cubic yards and extended only a quarter of a mile up the hill, but it put more silt in the main creek than had ever been recorded before. A sample of the water contained 666 parts per million compared to the normal of about 2 or 3 ppm. The second storm was even more severe, and lasted three days. Half of the 12.5 inches total precipitation fell in one 24-hour period. This storm too caused slides, one of which took out a 6-foot culvert, fill, and small wooden bridge. Untold volumes of debris and soil went into the main creek, and the silt content reached 820 ppm.

So far, we know very little about what causes such slides or how they can be controlled. The soil on which they occur is characteristic of the mid-elevations, much of it fine timber-producing land. In uncut timber the trouble spots are difficult to locate and even if we could identify them, we have no evidence now that it would be practical to attempt bypassing such areas.

Interception Study (FS-1-w1-3)

Analysis of preliminary data from the interception study started last August showed an average interception of 24 percent during the period when hardwoods and underbrush still held their leaves. Preliminary data from one plot on which we continued observations

on into the winter season, indicated that average interception of winter rains drop to about 19 percent. These are gross interception figures with no correction for stemflow.

## SISKIYOU-CASCADE RESEARCH CENTER

--- BY Gene Herring

### A Flow Divider for Use on Runoff Plots (FS-1-w3-1)

This winter we have developed and are testing a flow divider using standard pipe fittings. The current model consists of a one-inch tee with 3/4- and 1/4-inch reducer bushings and nipples. It is designed for use on runoff and erosion plots to obtain an aliquot sample of the runoff and suspended sediment. In operation it is attached to the outlet of an automatic siphon which periodically drains a 55-gallon drum. Heavy sediment settles out in this drum and about 15 percent of any overflow and its suspended sediment discharge through the divider into a second drum. This arrangement can give us a sample representing 415 gallons of runoff, it is relatively inexpensive, and is quite portable. The relative sizes of the two discharge tubes can be changed to give a wide range of capacities.

The automatic siphon is necessary to provide a strong rate of flow--the divider will not function properly for trickle flows. We are still testing the siphon, but it appears promising. Each divider must be calibrated individually because of the size differences between pipe fittings, but in a series of 13 trial runs, the mean discharge of the 1/4-inch tube of one we built was 15.17 percent of the total overflow, with a standard deviation of 0.11.

### Let's Have More Basic Research

The primary activity of this center to date at least, has been problem and project analysis. Writing project analyses puts one in a philosophical frame of mind, and our major contribution this time is in that vein.

Increasing emphasis on more basic forms of watershed management research is very encouraging. I am afraid that most of the research to date has been valuable only insofar as it has given us some clues to the possibilities of watershed management. Too often our studies tell us what can happen under a specific set of conditions, but fail to tell us why it happens. Until we learn some of the "whys", we will have difficulty extending the results to locations having somewhat different conditions.

In the past, we have partially met the problem of extending research results by establishing field stations or experimental areas in

localities which were considered to be typical of a given range of conditions. It is a valid approach while we are dealing in generalities, trying to typify conditions over rather large regions with generally similar conditions. But, when we deal in specifics -- as we must do if our research is to be of most use to the practicing land manager -- it becomes economically impractical, and in many cases impossible, to sample every significantly different set of environmental conditions.

Southwestern Oregon is an excellent case in point. The Siskiyou-Cascade Research Center is responsible for forest management and watershed management research in the five southwest counties of Oregon--a relatively small area of some 12,700 square miles. But even in this small area, we have a baffling complex of conditions.

Normal annual precipitation ranges from 16 to 120 inches. Over sizeable areas, several years may elapse with no trace of snow, while others have an annual accumulation of 10 to 12 feet.

The region is in a double ecotone, with a mixture of the typical Douglas-fir zone vegetation types and the eastern Cascade pine types. Super-imposed on this is a mixture of types characteristic of the Pacific Northwest and the California types of the south. The result is a highly complex conifer forest and an even more complex series of brushfields.

Soils range from loose, erodible sands and pumice to very tight clays.

Geologically, we have recent volcanics on top of older volcanics in the Cascade Range, Coast Range sedimentaries, and the igneous intrusives of the Siskiyous. Each is a complex formation.

Any desired combinations of slope and aspect could probably be found with little difficulty.

Obviously, with such diverse site factors, it will be impractical to set up an experimental area for every possible combination of conditions, or even for the more important combinations.

Faced with such a problem, we have three alternatives. We can do as has been done in the past--group and regroup until we have four or five environmental complexes and conduct empirical studies in each. This will give us some of the answers we need, but again we are forced into generalities. We still will never be able to extend our results outside the immediate experimental area with complete confidence.

As a second alternative, we could arbitrarily select four or five of the most important combinations of conditions, and conduct intensive empirical studies on these few combinations. Such a program would adequately serve the needs of the land managers working

with the specific set of conditions selected, but would leave many critical problems of other environments unanswered.

The third alternative is basic research on plant physiology, hydrology, and soil physics. In this way we may learn why certain things happen, and how certain factors operate. Knowing the "whys" and "hows" of watershed management we will be in a better position to predict accurately what will happen with any given set of conditions. Basic research will require expensive and elaborate laboratory facilities, and the answers we need will not be easy to obtain, but we think that in the long run such research will prove to be the most economical, in terms of both money and time.

The ideal research program would probably be a combination of the three alternative listed above; but without basic research we may be like the three blind men who attempted to describe the elephant after having touched him only once.

## BLUE MOUNTAIN RESEARCH CENTER

--- by Norman H. Miner

### Snow Reconnaissance Study (FS-1-w1-2)

This winter we started a study that should give us a lot better idea of why snow behaves the way it does in the Blue Mountain Province. Snow accumulation and melt is being measured at two distinctly different areas. One is at Tollgate in the central Blue Mountains north of LaGrande, Oregon. (Elevation 4000 - 5000 feet) and the other at Anthony Lakes in the Elkhorn Mountains west of Baker, Oregon (elevation 5000 - 6000 feet). Relation between environmental characteristics and snow behavior will be determined by multiple regression analysis. Environmental variables include elevation, slope gradient, aspect, size of openings and shelter, and crown density.

As an aid in this study, we are developing a "sun-arc grid." It is a plastic scale designed to evaluate oblique and lateral crown density. We are particularly interested in the portion of the crown cover that intercepts direct solar radiation.

A preliminary snow survey in March revealed a pronounced variation in snow depths and water content between the two areas. At Tollgate, the lower elevation area, snow depths averaged 90 inches, while snow at Anthony Lakes averaged 45 inches. Average water content at each of these areas was 30 inches and 13 inches, respectively. Differences are probably due to orographic influences: Tollgate is near a summit, while Anthony Lake is in the lee of a higher summit.

Skid Trail-Runoff (FS-1-w5-2)

In cooperation with the Wallowa-Whitman National Forest we established trough and barrel catchment installations on six skid trails during October. We want to measure amounts of water and soil flowing from 100- and 200-foot segments of these skid trails. The installation will be revised because winter runoff exceeded our expectations and the barrel capacity.

In order to test the effectiveness of seeding in reducing skid trail erosion, we've paired the trails and seeded one of each pair with the standard mixture used by National Forest Administration in this area: hard fescue, timothy and orchardgrass.

## MID-COLUMBIA RESEARCH CENTER

--- by David D. Wooldridge

Soil Disturbance Due to Logging (FS-1-w5-2)

In our last report we described some results of our study to determine the relative disturbance caused by two types of logging: tractor and Wyssen Skyline Crane. One phase of the study was to measure the effects of logging on soil properties. Analysis of the results revealed no significant differences at the 95 percent level but still, some trends are indicated. As only five sites in each logging type were sampled for soil disturbance (five sites on 800 to 1,000 acres), variation among samples from the same logging areas was large.

The following tabulation summarizes the effects of the two types of logging on total soil porosity and on macropore space. The apparent increase in macropore space due to Wyssen logging is probably a sampling error. The two areas represent different soil types, so that evaluations must be confined to differences between types of disturbance within a given logging method:

| Types of disturbance | Total Porosity Percent | | Macropore Space Percent | |
|---|---|---|---|---|
| | Wyssen | Tractor | Wyssen | Tractor |
| Undisturbed | 56.2 | 62.1 | 18.2 | 27.0 |
| Litter disturbance 1/ | 52.0 | 57.8 | 20.6 | 22.1 |
| Shallow soil dist. 2/ | 52.9 | 58.6 | 19.2 | 21.9 |
| Deep soil disturbance 3/ | 51.9 | 54.1 | 18.7 | 19.1 |

1/ Litter disturbance. Indicated by breaking down of brush and reproduction, and disturbance to litter cover, but litter and soil cover not removed.

2/ Shallow soil disturbance. Indicated by removal of litter and humus exposing the mineral soil to a depth of less than one inch.

3/ Deep soil disturbance. Same as 2 above only disturbance exceeds the one-inch depth.

Miscellaneous

Wooldridge presented a paper at the Soil Science Society meeting in Atlanta in November 1957 on the use and application of an air pycnometer and an aggregate analysis machine developed in the Center's soil laboratory. An article describing these instruments is now in preparation.

## BULL RUN PROJECT

--- by N. Bethlahmy

Gaged Watersheds (FS-1-w7-6)

Activities in the three gaged watersheds in the Bull Run area continued to demand a large portion of our time. A new 100-inch storage gage was installed at an accessible site at an elevation corresponding to the headwaters of these watersheds. The cone-shaped gage of galvanized steel has an orifice 10 inches in diameter, is over three-feet high, and is equipped with an Alter shield. The gage is set upon a 10-foot-high steel tower built from discarded steel members of Bonneville Power Administration towers.

Although this winter proved to be extremely mild (according to some, the mildest in a century), access to the gaged watersheds was still a problem and snow-shoes (in preference to skis) proved to be part of the standard equipment of watershed researchers. Although our winter "lodge" (a 12 x 15 foot cabin) was equipped for overnight occupancy, it was not needed as such this year. However, it was put to good use as a warm-up place during trips into the watersheds.

Research as a Cooperative Endeavor

All of our research is performed on Federal lands administered by the Forest Service. The success of our endeavors depends to a large extent on the full cooperation of the Forester administrators and also of the City of Portland authorities. It is essential that these administrators appreciate our problems, and that we, in turn, understand their difficulties. The problem of mutual understanding is complicated by the rapid turnover of personnel in National Forest Administration. During this period, a meeting was held with newly

assigned Zig Zag Ranger Station personnel to acquaint them with our work and to learn their long-range plans. In addition, an overnight snow-shoe hike into the headwaters of the Bull Run drainage was undertaken with city officials, and problems of mutual interest were discussed.

Erosion from Logging (FS-1-w5-2)

The City of Portland is preparing a site for a new dam and reservoir. Site preparations include clearing the entire reservoir area. These activities afforded us the opportunity of installing plots to ascertain the erodibility of the local soils. In addition, together with the Forest Economics Division, a new photographic technique for evaluating erosion is being tested.

Strip-Cutting (FS-1-w7-4)

In cooperation with the Mt. Hood National Forest we are incorporating some cutting treatments in a forthcoming timber sale in an area adjoining the Bull Run watershed. Plans call for cutting the old-growth Douglas-fir in strips of various widths to determine the optimum width for snow accumulation.

Miscellaneous Activities

Bethlahmy was designated program chairman for the annual meeting of the Pacific Northwest Section of the AGU.

## Publications

Bethlahmy, Nedavia and Anderson, H. Kenneth
January 1958. Watershed Research in Portland, Oregon. Jour. American Water Works Association. 50(1):110-114.

Dunford, E. G.
January 1958. Watershed Management Research in the Pacific Northwest. Journal of Soil and Water Conservation. 13(1):23-26.

Miner, Norman H. and Trappe, James M.
October 1957. Snow Interception, Accumulation, and Melt in Lodgepole Pine Forests in the Blue Mountains of Eastern Oregon. Pacific Northwest Forest and Range Expt. Sta. Res. Note 153, 4 pp., illus. (Processed).

SEMIANNUAL REPORT--October 1957 through March 1958
Division of Watershed Management Research
Rocky Mountain Forest and Range Experiment Station

## ALBUQUERQUE

Accuracy of sediment sampling (San Luis watersheds - Rio Puerco)

The problem of measuring sediment accurately in the arid Southwest is a tough one. Any method that samples only a portion of the suspended or bed-load sediment in runoff water or streamflow will provide, at best, a very crude estimate of total sediment. The only approach for research is to trap all of the sediment in a reservoir and measure the deposition by weight and volume. This in itself is a major undertaking, particularly when sediment inflow by storms is desired.

At San Luis it is not feasible to sample suspended sediment in runoff water prior to its entrance into the reservoirs. Yet there is a need for sampling sediment in water flowing over the spillways and that passing through the outflow culvert pipe on the middle watershed II.

In the first years after this study was started we attempted to sample the sediment content of water leaving the reservoirs. Since we did not have a man stationed on these watersheds during the summer storm period, our chance of being on the watersheds during storms was rather small. Yet in these dry years water seldom passed over the spillways. We were interested in learning how much sediment spilled out of reservoir II through the 8-inch diameter outflow pipe. The USGS specialists had assured us that this quantity was indeed a very small part of the total load of sediment. We accepted this hypothesis because it seemed reasonable that the reservoir, acting as a stilling pond, would allow most of the sediment inflow to settle in the reservoir and water flowing through the outflow pipe would have a low concentration of sediment.

In July 1955 the first sediment sample was taken in water flowing through the outflow culvert pipe of watershed II in the major storm to that date. The sample contained 16,000 parts per million. This set the stage for more intensive sampling.

In 1956 rising stage water samplers (1-pint capacity) were installed on all 3 spillways and in the outflow pipe of W-II. The year 1956 was the driest in recent times but it was followed by a wet year in 1957. Seven storms in 1957 produced waterflow through the outflow pipe on W-II.

One sediment sample was obtained from the center of the 8-inch diameter pipe on W-II during each of the first 3 storms. Samples in subsequent storms were taken 2 inches from the top and 1 inch from the bottom of the pipe. These values are tabulated.

| Storm date | Sampling location | Sediment concentration (Weight basis) |
|---|---|---|
| July 24-26 | Center | 3,850 |
| August 5-6 | Center | 1,450 |
| August 9 | Center | 1,640 |
| August 31 | Low | 17,100 |
| | High | 3,900 |
| October 12 | Low | 24,600 |
| | High | 25,300 |
| October 18-21 | Low | 105,000 |
| November 16 | Low | 2,940 |

The above data indicate a tremendous variation and large sampling error as well as casting doubts on the accuracy and reliability of this method. This same sort of variation is found in measuring water flowing over the spillways. Obviously our previous measurements of sediment deposited in the reservoir of W-II fall far short of representing total soil washed off the watershed. Yet this watershed has a rate of sediment deposition in the reservoirs of well over 1 acre-foot/square mile/year.

We intend to intensify the number of samples taken in 1958 and install some sort of aliquot sampler. We still lack confidence in any presently available method for measuring suspended sediment. My experience with intensive sampling using the swordfish sampler (Bates) on the Whitewater River in southeastern Minnesota in 1939-40 was even more discouraging. I recall obtaining a tremendous variation between samples taken at the same place and the same water depth during flood flows in the Whitewater River and tributaries.

Soil moisture at Pine Flat (Manzano Mountains)

Soil water failed to penetrate to the limestone bedrock at 30 inches on plots under blue grama grass or pinyon pine trees in 1957, at Pine Flat. Yet the year 1957 was wet at Pine Flat, according to the 45-year U. S. Weather Bureau record at nearby Tijeras Ranger Station. Pine Flat, at 7,340 feet, approximates an average of 17 inches annual precipitation on the basis of correlation with that of the Tijeras Ranger Station. The 1957 total annual precipitation at Pine Flat was 19.60 inches.

Annual precipitation fails to give the proper picture when considering soil moisture accretion and depletion. The distribution of precipitation is much more important. About 30 percent of the annual precipitation falls during the winter months, November through March. Most of this moisture comes as snow when vegetation is dormant and when evaporation-transpiration demand is at its lowest. Snow melts at a slow rate and consequently very little melt runs off the soil surface on areas covered with pine litter or blue grama sod. This period of low evaporation and low transpiration is the time when soil moisture might be expected to penetrate to bedrock at Pine Flat.

During the 4 previous over-winter periods at Pine Flat, soil moisture was never sufficient to penetrate to bedrock on the 2 vegetated plots. The total amounts received during the November 1 to April 1 period were:

| | Inches |
|---|---|
| November 1, 1953, to April 1, 1954 | 4.10 |
| November 1, 1954, to April 1, 1955 | 1.71 |
| November 1, 1955, to April 1, 1956 | 3.09 |
| November 1, 1956, to April 1, 1957 | 4.58 |

Although 1957 was a wet year, very little precipitation fell during November and December 1956; consequently over-winter precipitation was only slightly more than during the 1953-1954 period. Larger amounts of precipitation can be expected more than 40 percent of the time during this over-winter period of low moisture loss to the atmosphere.

The present over-winter period is already the wettest dormant season of record. By March 12, 1958, slightly over 7 inches of precipitation had been received since November 1, 1957. This is half again as much as previously received during the wettest season. Moreover, October was exceedingly wet with 3.20 inches of rain and snow.

By March 12 soil moisture had percolated beyond the 24-inch depth under both blue grama and pinyon pine cover. Soil moisture above the limestone at the 30-inch depth still remained below wilting point.

The moisture content of the snow on the ground on March 12 measured 2.4 inches on the blue grama plot and 1.7 inches under pinyon pine. We predict soil water will penetrate to bedrock before April 1 of this year.

New publications

A new publication in 1957 was:

Pingrey, H. B., and Dortignac, E. J. 1957. Cost of Seeding Northern New Mexico Rangelands. N. Mex. Agr. Expt. Sta. Bul. 413, 43 pp., illus.

This paper covers the first phase of our joint investigative project with State College. We are presently summarizing the results of phase 2, which involves the economic benefits of grazing crested wheatgrass. Though this is a range publication, it may have interest to those interested in economics and the possibilities for evaluating the water resource, economically. One section on risk and uncertainty in relation to weather and time of seeding and another on the relation between forage yield of native grasses and precipitation are of watershed management interest.

E. J. Dortignac

Beaver Creek Project

The project has expanded since our last writing with the addition of 3 more pine watersheds ranging in size from 100 to 600 acres. This fall they were equipped with flumes, 2 recording precipitation stations, and 3 standard stations. With the addition of these 3 watersheds, the totals are as follows:

6 pine watersheds, 100-2,200 acres, elevation 7,200 feet
3 alligator juniper watersheds, 150-300 acres, elevation 6,200 feet
3 Utah juniper watersheds, 140-400 acres, elevation 5,200 feet

The 1957 precipitation as measured at a weather station within each type averaged:

| | |
|---|---|
| Pine | 42.72 inches |
| Alligator juniper | 32.38 inches |
| Utah juniper | 27.06 inches |

Mean temperature differences in the 3 types were:

Maximum - Pine 4° cooler than alligator juniper
Maximum - Alligator 8° cooler than Utah juniper
Minimum - Pine 7° cooler than alligator juniper
Minimum - Alligator 6° cooler than Utah juniper

There is a consistent difference of at least 12° in both maximum and minimum temperatures between 7,200 feet (pine) and 5,200 feet (Utah) elevations.

Streamflow measurements for rating purposes are continuing in our modified trapezoidal flumes. Winter discharges haven't exceeded 15 cfs to date. Contrasting this with the 380 cfs received from a summer thunderstorm of last year gives some idea of the variability of discharge from southwestern watersheds.

Other work

Skau has completed his study plans and is preparing for field season. He is installing interception, soil-moisture, root-exploration, and surface-runoff studies in the Utah juniper type.

The pine-pole-interception and litter-moisture data collected last year are nearing final computation. Results should be available at our next writing.

Snow pictures

For those who missed it, Newsweek magazine had in its December 30, 1957, issue a special report on the "Winter Camera." It illustrated some excellent snow pictures and the techniques used to take them. For a fast picture (avalanche or sliding snow) use Verichrome pan film

f-8 at 1/500, K2 filter. For excellent pictures of snow on trees, use f-32 at 1/10 with a G filter. Underdevelop negatives to get detail in snow scenes, otherwise the snow looks like cotton. For water and snow (a stream), use orange filter, f-16 at 1/100. The medium yellow or orange filter darkens the blue shadows in the snow and clarifies the separation between sky and snow. During a snowstorm use f-5.6 at 1/100, and to keep snow off lens a large shade should be used.

E. F. Aldon

## FORT COLLINS

### A comparison of estimated and measured melt water production from alpine snow during the summer

For the past 3 summers the product of vertical ablation and density has been used as an estimate of the melt water released from alpine snowfields. An opportunity to check the accuracy of this type of estimate arose during the summer of 1957 while snow evaporation experiments were being conducted.

Melt water from plastic-lined pits buried in a snowfield and containing 150 cubic feet of snow was measured at frequent intervals. Vertical ablation was read from 3 stakes in the surrounding snowfield, and density determinations were made about every 2 weeks. A comparison of the melt water expected from the density-ablation estimate and the measured melt water is shown in table 1. All entries except the first are for 24-hour periods. The first is for 69-1/3 hours.

The sum of estimated melt, precipitation, and net moisture exchange (condensation was taking place at all times for which data are available) was found to be within 3 percent of the measured melt water on 8 of the 10 dates.

These preliminary data offer considerable encouragement for the use of the ablation-density method of estimating melt water production from alpine snowfields under summer conditions.

Table 1.-- Comparison of measured and computed melt water, August 1957

| Date | Estimated melt: (Ablation x density) | Precipitation | Net moisture exchange | Total computed water | Measured water | Computed / Measured x 100 |
|---|---|---|---|---|---|---|
| | Inches | | | | | Percent |
| 7-10 | 6.42 | 0.14 | a/ | 6.56 | 6.45 | 102 |
| 10 | 1.99 | 0 | a/ | 1.99 | 1.95 | 102 |
| 22 | 2.76 | .03 | .06 | 2.85 | 2.85 | 100 |
| 23 | 2.03 | 0 | .02 | 2.05 | 2.11 | 97 |
| 24 | 1.84 | 0 | a/ | 1.84 | 2.09 | 88 |
| 25 | 2.07 | .10 | a/ | 2.17 | 2.16 | 100 |
| 26 | 2.56 | 0 | a/ | 2.56 | 2.59 | 99 |
| 27 | 1.77 | .10 | a/ | 1.87 | 2.25 | 83 |
| 28 | 1.29 | 0 | .02 | 1.31 | 1.33 | 98 |
| 29 | .86 | .03 | a/ | .89 | .88 | 101 |

a/ Condensation-evaporation data not available.

M. Martinelli

## Fool Creek

The treatment of Fool Creek, completed in the fall of 1956, caused an apparent 200 acre-foot increase in water yield during 1957, from the start of the spring freshet to September 30. This compares with a 250 acre-foot increase in 1956, following 80 percent completion of the timber harvest. It is believed that the difference is merely such as is to be expected between years and not indicative of any trend with forest recovery. As in 1956, the yield throughout the spring, summer, and early fall period was greater than predicted, but the August and September excesses were statistically nonsignificant.

## Snow evaporation and sublimation

A beginning has been made in some fundamental, laboratory-type observations of snow sublimation. The present objectives are: (1) to determine if the vapor pressure of snow is different from that of ice, (2) to compare the sublimation rates of snow and ice, and (3) to test the evapo-sublimation potential in a forest for evidence of a gradient with elevation above the snow pack surface. The latter is pertinent because of the abundant, but indirect, evidence that intercepted snow evaporates and/or sublimates more rapidly than does snow on the surface of the pack.

For the first objective, identical vessels are filled with snow and ice, respectively, and exposed in an air-tight container to ambient temperatures constantly below freezing. A differential loss in weight indicates a vapor pressure differential. One test with snow several days old (partially ripened) revealed no vapor pressure difference. One test with newly fallen snow suggested that the vapor pressure of the snow was the higher, but the results were not conclusive. Further tests will be made.

For the second objective, snow and ice in separate identical vessels, and calcium chloride in a third container, are exposed in an air-tight chamber. A midget D. C. motor with propeller blade provides circulation within the chamber to hasten the vapor transport over that dependent on diffusion alone. However, during tests of more than 1 day the fan operation was only sporadic because of battery failure associated with low temperatures. All tests were run with ambient temperatures below freezing.

These tests, like those above, have not yet been such that definite quantitative conclusions can be drawn. However, almost all results to date indicate a higher sublimation rate from snow than from ice per unit of gross surface area. In these tests there is the influence of the particulate nature of snow with its greater effective surface per unit of gross surface.

One test lasting approximately 10 days is of interest for the measured sublimation of ice. The ice was exposed in a vessel approximately 4 inches in diameter and 1/2-inch deep. The loss in mass during the test was about 12 percent of the initial mass, or 0.06 inch in depth. The temperature range during the period was between +28° and +14° F. The circulating fan was not operated during this test. In the same period, the dish of snow ripened and sublimed to the point where the bottom of the dish was no longer completely covered. In all tests the volume of shrinkage of the snow mass by firnification was marked.

The third objective was approached by suspending cones of ice from a vertical mast projecting through the crown of a 30-foot lodgepole pine. A cone was formed by freezing ice in a paper cup through which a length of string had been run and sealed to the cup apex with paraffin. A small disk of wood, positioned by a knot in the string, was frozen into the cone at midlength to prevent the cone from sliding down the string when melting occurred. The cone was suspended in position by the string and a small can similarly suspended from the cone to catch any melt water. Transformer oil in the can prevented evaporation.

In the 2 bug-proof tests to date, 1 cone was exposed beneath the tree crown about 6 inches above the snow pack surface. A second cone was exposed within the crown 8 feet above the snow. A third was within the crown about 20 feet above the snow pack. All cones were on the sunny side of the tree. In each test the exposure time was about 4 hours, from approximately 10 a.m. to 2 p.m.

The results from the first test were as follows:

| Cone position | Vaporization loss | | Melt loss | |
|---|---|---|---|---|
| | Grams | Percent of total | Grams | Percent of total |
| Top | 4.8 | 19 | 20.3 | 81 |
| Mid | 4.3 | 21 | 16.1 | 79 |
| Low | 3.9 | 26 | 11.3 | 74 |

A direct relation between height of cone and total of vaporization and melt may be noted. Of further interest is the fact that vaporization loss amounted to about one-fourth of the melt loss.

A second 4-hour test was run on a day when temperatures were such that no melt water drip from the cones occurred, although the sky was continuously clear. During the test the temperature in a nearby weather shelter ranged from 25° to 35° F. The dewpoint stayed constant at -1° F. There was an intermittent light breeze. It is possible that the cone ice did melt and that evaporation took place, although visual evidence indicates that all loss was of sublimation. The results were as follows:

| Cone position | Vaporization loss | |
|---|---|---|
| | Grams | Percent of initial weight |
| Top | 10.2 | 11 |
| Mid | 9.3 | 10 |
| Low | 9.0 | 10 |

A trend of vaporization loss with position is not evident in this test. However, the magnitude of the loss from all cones is striking and suggestive of what may happen to intercepted snow and snow exposed beneath the sunny side of trees.

B. C. Goodell

## GRAND JUNCTION

### Black Mesa watershed studies

1957 was a year of record precipitation in western Colorado. On Black Mesa total precipitation from November 1, 1956, to November 1, 1957, was approximately 50 inches, or double the estimated long-term average. This provided a rare opportunity to observe and measure hydrologic characteristics of small watersheds under extreme conditions.

Runoff and sediment were measured on 3 gaged watersheds. Preliminary study of the records shows the following peak discharges:

| Watershed No. | Size (acres) | Peak discharge during snowmelt | |
|---|---|---|---|
| | | Runoff (cu. ft. per second) | Suspended sediment (Parts per million) |
| 4 | 86 | 4 | 765 |
| 5 | 161 | 9 | 1,830 |
| 6 | 272 | 12 | 675 |

Black Mesa is located on the Gunnison National Forest at an elevation of about 9,800 feet. The experimental watersheds have a mountain grassland cover interspersed with stands of aspen and spruce. Instrumentation to measure hydrologic factors has been installed during the past 3 years in connection with a study of the relationships between plant and ground cover and the production of runoff and sediment. Different grazing treatments were started on the watersheds in 1957. From this study a basis may be gained for predicting certain runoff and sedimentation characteristics from the plant and ground cover on a watershed.

An interesting phenomenon observed early in the 1957 snowmelt season was the sudden appearance of streams on top of the snow. These streams developed as the result of surfacing water tables in the snow and at times carried large amounts of sediment. Along the channels near stream gages 4 and 5 we found 1/4-acre patches of deep snow covered

with several inches of coarse sediment and litter which had been deposited by these over-the-snow streams.

Several summer storms produced measurable runoff at the weirs. Suspended sediment in runoff resulting from these storms was extremely variable, reaching a maximum of 11,510 parts per million on watershed 4.

H. E. Brown

## RAPID CITY

The Black Hills have been favored (?) with a dry, mild winter. No subzero temperatures were recorded at Rapid City till February 11 and no blizzard warnings were issued till near the end of February. The eastern Black Hills have been supporting their reputation for "banana belt" weather while areas to the east and south have been colder and received substantially greater amounts of precipitation, much of which it seems finally came to rest on roads and highways.

In fact, early winter was so mild that it was possible to do some field jobs--at the expense of pencil pushing and calculator punching. The statistical training course at Fort Collins, from October 14 to November 11, was a profitable interlude between the field season and the winter office work.

### Soil moisture

Considerable interest is developing in moisture use by different stand densities of ponderosa pine. A study was started last summer.

Ponderosa pine reestablishes itself so easily in the Black Hills that dense second growth stands are common. In the area selected for study there were 2,106 trees per acre averaging 3.8 inches d.b.h. Basal area averaged 166 square feet per acre. Trees were spaced an average of 4 to 5 feet apart.

A part of the stand was clear-cut and a part was thinned to about 10 x 10 foot spacing, leaving a basal area of about 80 square feet per acre. A third part of the stand was left undisturbed.

Rain and stem flow gages were installed in September and measurement was started October 1. From that time to March 10 the area received 3.46 inches of precipitation, about 1.5 inches as rain to November 4, and most of the remainder as light snowfall. Maximum weekly precipitation in the form of snow was 0.40 inch which fell between February 27 and March 3.

Total through fall measured so far in the thinned stand is 2.83 inches or 82 percent of gross precipitation. Total through fall in the unthinned stand has amounted to 2.46 inches or 71 percent of gross precipitation.

So far there has been virtually no stem flow except during the rainfall period of last October. From October 14 to 21 rainfall was 0.69 inch. Stem flow from 1 tree in the unthinned area amounted to 32 pounds 5 ounces and averaged 16 pounds 6 ounces for 5 trees. Stem flow averaged 15 pounds 14 ounces from 5 trees in the thinned stand. On an areal basis this is about 5 percent of the gross precipitation. While these results are not yet really conclusive, they give us warning that we had better be prepared to weigh and empty our gages at frequent intervals during the May and June period of maximum seasonal precipitation-- or install larger gages.

Colman soil moisture units were installed to a depth of 7 feet during balmy December. Gravimetric soil moisture samples will be collected beginning in April and continuing throughout the summer. By fall we hope to have a fairly complete story of evapo-transpiration during the one season and enough data for calibration of the soil moisture units.

We are considering adding another thinning test to the study this summer, spacing trees more than 10 feet apart.

Soil compaction

Analysis of data collected for study of soil compaction in bluegrass stream bottoms has been completed. As previously reported, results show that the medium textured soils of the stream bottoms are compacted to a depth of about 4 inches by cattle trampling. Soil samples taken inside livestock exclosures of different ages suggest that from 6 to 10 years' protection is necessary before there is a significant degree of recovery in terms of bulk density and pore space of the soil.

Analysis of experimental error shows that we can rely on about the same intensity of sampling throughout the types of areas sampled. However, soil bulk density and pore space were significantly more variable to depths of about 6 inches inside exclosures than from 6 to 12 inches inside exclosures and from the soil surface to 12 inches outside exclosures. Surface layers inside exclosures must therefore be more intensively sampled to produce results with comparable level of confidence.

H. K. Orr

- TEMPE

Measurement of evapo-transpiration in the field

A field apparatus involving an infrared gas analyzer in circuit with a chamber that can be erected over a plant in the field is now being improved. To reduce turbulence in the plant chamber, a new type of plastic tent has been designed and built. The chamber is flat-topped with vertical side walls. It is hexagonal in horizontal section (5 feet on a side by 8 feet high). Walls and top are made of 6 mil (0.006 inch) polyethylene film supported on a framework of lightweight

steel tubing (3/4-inch conduit). The side wall is one continuous piece, containing six 8-foot uprights bolted permanently in place, all of which can be rolled and carried by one man. The top is also of one piece and is sealed to the side wall by a system of bolts and clamps. The tent can be erected by two men in about 15-30 minutes. It has withstood winds of about 20-25 m.p.h.

The system is being calibrated by direct reference to a primary standard. A large-surface, low-mass evaporator mounted on a direct-reading balance is inserted into the empty transpiration chamber. Weight loss corresponding to a given humidity differential x air volume combination is then read directly.

J. P. Decker

Ecology of phreatophytes

Every receding flow on the Salt River experimental area left a band of tamarisk seedlings at and below the high water mark. Subsequent high flows destroyed all seedlings by submergence or washing. The last high peak in early fall left a wide band of seedlings that are now 2 to 3 inches in height. This substantiates previous findings that saturated soils are needed for successful establishment of tamarisk seedlings.

Sprouting ability of tamarisk following cutting is being tested at the Salt River experimental area. Thirty-eight plants were cut approximately 6 inches above the crown, 13 plants were cut at the crown, and 35 plants were removed completely to 10 inches below the crown. Of the latter, 15 holes were left open exposing the cut roots, and 20 were refilled with soil.

Sprouting within the four treatments was as follows:

| | |
|---|---|
| Plants cut 6 inches above crown. . . . . | 100 percent |
| Plants cut at crown . . . . . | 100 percent |
| Plants cut 10 inches below crown and left exposed | 66.7 percent |
| Plants cut 10 inches below crown and covered . . . . | 40 percent |

Evidently, sprouting from roots of tamarisk could be a serious problem even if the root crowns of the mature shrubs were completely removed by mechanical means.

Seeds of Tamarix pentandra collected in the spring and early summer lose their viability within 10 weeks or less. Seeds collected in late summer hold their viability for longer periods. Germination of typical lots of seed is shown on the following page.

| Weeks after collection | Germination percent<br>Date of collection (1957)<br>5/10 | 6/6 | 7/19 | 8/19 | 9/30 |
|---|---|---|---|---|---|
| 0 | -- | 99 | 94 | 85 | 74 |
| 2 | -- | 95 | 91 | 98 | 93 |
| 4 | 94 | 94 | 79 | 95 | 77 |
| 6 | 98 | 60 | 6 | 92 | 62 |
| 8 | 92 | 41 | 0 | 96 | 17 |
| 10 | 72 | 13 | 0 | 79 | 44 |
| 12 | 20 | 0 | 0 | 90 | 13 |
| 14 | 0 | 0 | 0 | 67 | 24 |
| 16 | 0 | 0 | 0 | 70 | -- |
| 18 | 0 | 0 | 0 | 60 | 23 |
| 21 | 0 | 0 | 0 | 68 | 29 |
| 24 | 0 | 0 | 0 | 62 | -- |
| 27 | 0 | 0 | 0 | 72 | -- |

After they are thoroughly wet, fresh tamarisk seed germinate in 24 hours, seed stored 10 weeks germinate on the second day, and seed 15 weeks old require 3 days for germination if still viable.

Cool temperatures prolong viability of tamarisk seed. Some seed lots were stored in the office (approximately 72° F.) and others stored in the refrigerator (approximately 40° F).

Germination percents were as follows:

| Weeks after collection | Germination percent<br>72° | 40° |
|---|---|---|
| 6 | 80.9 | 78.9 |
| 8 | 62.0 | 64.4 |
| 10 | 51.4 | 64.7 |
| 12 | 28.1 | 64.1 |
| 14 | 25.5 | 60.8 |
| 16 | 23.2 | 60.3 |
| 18 | 21.0 | 59.0 |

Germination of Baccharis glutinosa seed collected in the spring and summer of 1957 was usually less than 5 percent and only rarely reached 20 percent. Seed collected in late September and October gave erratic germination usually below 50 percent but sometimes as high as 85 percent.

J. S. Horton

Tamarisk and soil salinity

Conductivity measurements of surface soil samples (0-2 inches) collected under tamarisk when compared with adjacent areas indicate that tamarisk markedly increases the salinity of its immediate environment. Transects were laid out under tamarisk, and in adjacent areas where this plant was lacking. Samples were collected at 6-foot intervals to

a depth of 2 inches along these transects. Conductivity tests of the saturation extract were as follows:

| Transect No. | Conductivity | |
|---|---|---|
| | Under tamarisk | Adjacent to tamarisk |
| | millimho/cm | |
| 1 | 5.7 | 3.7 |
| 2 | 5.0 | 0.7 |
| 3 | 5.7 | 0.4 |
| 4 | 2.0 | 1.5 |
| 5 | 8.5 | 0.2 |
| 6 | 31.9 | 2.3 |
| 7 | 13.0 | 0.6 |
| 8 | 32.5 | 0.6 |
| 9 | 68.5 | 0.6 |
| 10 | 33.1 | 0.6 |
| Mean | 20.6 | 1.1 |

J. B. Secor

Timber harvest in mixed conifer forest has little effect on streamflow

Timber harvest and stand improvement work removed 36 percent of the original basal area of all trees 1 inch and over from the 318-acre watershed on the South Fork of Workman Creek. Work commenced in 1953 was completed during July 1956. The first year's streamflow data since completion of this treatment plot above the regression line for the pretreatment data by almost 5 percent. If future years' data follow the same pattern, approximately 30 years will be required to establish statistical significance.

Forest and chaparral roots penetrate deeply into the soil mantle

Depth, density, and location of roots were sampled from trenches dug at 3 locations on Sierra Ancha Experimental Forest. Two locations were in Workman Creek where rainfall averages 31.5 inches. One trench was established under a stand of ponderosa pine at elevation 7,450 feet and another under a mixed stand of ponderosa pine, white fir, Douglas-fir, and Gambel oak at elevation of 7,000 feet. The third trench was in chaparral (shrub live oak), Wright silktassel, hollyleaf buckthorn, pinyon pine, skunkbush sumac, and desert ceanothus at an elevation of 4,700 feet where rainfall averages about 20 inches. Roots were screened from cubic-foot soil samples (1 foot x 1/2 foot x 2 feet), at random locations along the trench walls. Some sections were extended below the floor of the trench with an auger.

Average air-dry weight of roots ± standard deviation from 11 sections in the mixed pine site and 10 sections from the ponderosa pine and chaparral sites are tabulated below:

| Depth at which samples were taken | Ponderosa pine Elevation 7,400 | Mixed pine Elevation 7,000 | Chaparral Elevation 4,700 |
|---|---|---|---|
| Feet | Weight of roots in grams per cubic foot | | |
| 0-2 | 1/ 160.2 ± 73.5 | 1/ 233.4 ± 172.4 | 1/ 73.5 ± 33.0 |
| 2-4 | 54.1 ± 17.0 | 65.0 ± 89.7 | 56.6 ± 39.0 |
| 4-6 | 11.4 ± 8.5 | 19.5 ± 7.2 | 21.0 ± 7.6 |
| 6-8 | 5.0 ± 3.4 | 14.7 ± 10.1 | 23.6 ± 9.3 |
| 8-10 | 2/ 5.2 ± 4.0 | 6.8 ± 3.6 | 8.3 ± 5.6 |
| 10-12 | 3/ 1.1 ± 1.0 | 4/ 3.0 ± 1.9 | 7/ 13.0 |
| 12-14 | | 5/ 1.3 ± 0.3 | |
| 14-16 | | 6/ 0.8 ± 0.02 | |
| 16-18 | | 6/ 0.2 ± 0.01 | |

1/ Mean value ± standard deviation
2/ Six samples, four of which were taken by auger
3/ Four auger samples
4/ Four samples, one of which was taken by auger
5/ Three samples, two of which were taken by auger
6/ Three auger samples
7/ One auger sample

Most roots of all sizes were near the surface. Smaller roots were found as deep as it was possible to take samples.

Water increases accompany conversion from chaparral to perennial grass

Chaparral shrubs were killed by basal spray on a watershed of 12.14 acres during 1954. Perennial grass took over the areas occupied by shrubs. An adjacent watershed of 9.07 acres was not treated. Water yield data were tested by analyses of covariance to determine if differences resulted from treatment. If the differences in flow continue as at present, statistical significance can be established in approximately 8 years.

Preliminary runoff from ponderosa pine watersheds

Two watersheds (East and West Forks of Castle Creek) near Beaverhead, Arizona, with ponderosa pine cover at 8,000 feet elevation were selected in 1955 for calibration and subsequent timber harvest. Weirs were completed in November 1955. First streamflow occurred in March 1956.

These are definitely intermittent streams. However, much of the ponderosa pine in the Southwest is found on small watersheds that do not produce perennial streamflow. Consequently, it seems worthwhile to study effects of land treatment on these areas even though part of any gain in water may be required to satisfy an existing soil moisture deficit.

These watersheds sample a rainfall pattern where growing season moisture exceeds winter moisture, in contrast to the Sierra Ancha watersheds where winter moisture is greater than summer moisture. The following tabulation compares precipitation and runoff for the first 2 years following calibration:

Precipitation and runoff (in inches)
Castle Creek watersheds

| Month | East Fork | | West Fork | |
|---|---|---|---|---|
| | Precipitation | Runoff | Precipitation | Runoff |
| | Beaverhead | | Log Canyon | |
| 1955-56 | | | | |
| October | 1.15 | 0 | | 0 |
| November | .56 | 0 | | 0 |
| December | 1.18 | 0 | | 0 |
| January | 1.76 | 0 | | 0 |
| February | 2.19 | 0 | | 0 |
| March | 0 | .058 | | .018 |
| April | .82 | .005 | | .007 |
| May | .69 | 0 | | .004 |
| June | 1.31 | 0 | | 0 |
| July | 2.53 | 0 | | 0 |
| August | 2.03 | 0 | 1.93 | 0 |
| September | .28 | 0 | 0.30 | 0 |
| 1956-57 | | | | |
| October | 1.24 | 0 | 1.33 | 0 |
| November | 0 | 0 | 0 | 0 |
| December | .34 | 0 | .38 | 0 |
| January | 4.13 | .005 | 3.64 | .001 |
| February | 1.36 | .037 | 1.35 | .005 |
| March | 2.13 | .056 | 2.22 | .021 |
| April | 1.51 | .012 | 1.60 | .012 |
| May | 2.14 | .039 | 2.27 | .016 |
| June | 1.89 | T | 2.53 | .002 |
| July | 5.61 | .161 | 5.90 | .187 |
| August | 9.51 | 1.169 | 8.84 | 1.166 |
| September | .35 | .361 | .38 | .101 |
| 1957-58 | | | | |
| October | 4.06 | .095 | 4.21 | .026 |
| November | 1.49 | .145 | 1.04 | .080 |
| December | .59 | .010 | .61 | .010 |

L. R. Rich

Shrub recovery and grass regeneration following burning on Mingus Mountain

Remeasurement of line transects and forage production sample plots on the area burned by the Mingus fire of June 1956 was completed in December 1957. Assisting in this cooperative study were the University of

of Arizona, the Prescott National Forest, and the Arizona Game and Fish Department. Data have not been analyzed; but it is apparent that scrub oak, mountainmahogany, and skunkbush have sprouted vigorously following top kill by fire. Pointleaf manzanita and desert ceanothus have not sprouted but seedlings of these species are common. Partial to complete burial of steel plot-marker stakes indicates considerable movement of soil, especially along the lower edge of the burn.

C. P. Pase

Cooperative chaparral watershed-game management study on 3-Bar unit

This study, aimed at determining the effects of plant-cover changes in chaparral on water and game, was initiated in 1955. Weirs were installed on 4 small watersheds and water yield has been measured since the summer of 1956. Instruments and construction materials were supplied by Salt River Valley Water Users. Readings are made by the Arizona Game and Fish Department during summer, and by Tonto National Forest during the remainder of the year. Mapping of vegetation on one watershed was completed in 1956 and indicated need for a revised sampling method. The Arizona Game and Fish Department is making counts of pellet groups dropped by deer on the watersheds.

Additional watersheds under construction in the chaparral type

Stream gages are being built on two watersheds in the White Spar area,approximately 200 acres in area, near Prescott, Arizona. Access roads were completed in February 1958. Water-measuring devices including V-notch weirs and San Dimas flumes are under current construction. Preliminary rainfall and crest flow observations are being made on several other watersheds on the Prescott National Forest.

G. E. Glendening

SEMIANNUAL REPORT

Division of Watershed Management Research
Southeastern Forest Experiment Station

October 1957 - March 1958

## COWEETA HYDROLOGIC LABORATORY

### Progress on Coweeta Studies

FS-1-w7-2-SE. Hardwood sprouts, blackberry briars and grapevines which continually seem to grow better than planted pine have been removed from Watershed 17 in a second release cutting since the pines were set out in 1955. Watershed 1, which was planted to white pine last spring, has also been released; and due to the extremely dry summer months also needed considerable replanting which was accomplished this spring. According to a recent study on Watershed 1, black locust seemed to be the principal offender, apparently thriving on areas that were burned between brush piles. The brush piles were part of the clearing operation and were burned to facilitate planting the pines.

FS-1-w1-6-SE. A soil moisture-elevation study, completed last year, is slated for more observations and further analysis work, with emphasis on tying down the variation of bulk density samples and the instrumentation problems associated with measuring this elusive parameter of the soil.

FS-1-w1-7-SE. Work is also continuing on Watershed 22, where alternate 33-foot strips were clearcut (deadened) in 1955: fast-growing hardwood sprouts have been cut back, maintaining the 50-percent"cut." This is one of a series of studies to yield information on water yield and its relation to various stand variables including basal area.

FS-1-w7-6-SE. Watershed Units 40 and 41 (our integrated timber-water resource management pilot study) are undergoing a re-appraisal in view of the difficulties of applying standard logging and silvicultural techniques to small areas. The work is of the office variety and a sound working plan is the objective. The plan will be worked out with additional studies in mind, the overall goal being a comprehensive and useful series of watershed pilot projects to demonstrate these types of land management.

FS-1-w6-4-SE. The three poor-practice studies of mountain farming, woodland grazing, and mountain logging are in rehabilitation phases in varying degrees. The mountain farm is now densely covered with vegetation, a considerable part of which is white pine and yellow poplar planted at the inception of the present study phase. The grazed watershed is still a valuable demonstration area since regrowth of understory trees and shrubs has been extremely slow,and the area still resembles a heavily used park. The logged watershed is undergoing rehabilitation work, aimed principally at stabilizing logging roads and skid trails to improve drainage and reduce the sediment contributions to the main stream.

Interception in a Cove Hardwood Stand (FS-1-w1-3-SE)

Pete Black's year-long interception study in Barker's Cove has yielded interesting observations and conclusions concerning instrumentation. Gross precipitation, throughfall, and stemflow were measured. Four standard rain gages were used to measure gross precipitation, three under vertical and one under 45-degree openings in the crown canopy. Variation in catch between gages was considerable but there were no consistent differences.

An analysis of variance showed that throughfall was not significantly different between seasons or between plots (on which the gages were randomly moved). An arcsin angular transformation of the data, however, showed a significant difference between seasons, but no significant difference between plots. The regression equations of throughfall on gross precipitation were in close agreement with several other studies in this country and in Africa.

Interception loss, not corrected for stemflow, was 10.4 percent of gross precipitation on an annual basis. Throughfall for the year was 73.24 $\pm$ 0.15 inches and gross precipitation was 81.79 $\pm$ 0.17 inches, indicating that the ratio of throughfall gages to gross precipitation gages used, 9:1, is sufficient in the forest type studied to maintain consistent error in the two parameters. Stemflow, only slightly higher than the error associated with gross precipitation, is not worth measuring considering the high cost. It would be better if an estimate of stemflow can be substituted for its measurement. Further, stemflow variation was high, and results from the sixteen gaged trees yielded insufficient data upon which to base sound conclusions concerning variation and prediction.

## Weather

Precipitation at Coweeta last summer was among the lowest of record. Precipitation of 0.30 inches fell in July (driest on record with a twenty-year average of 6.39 inches) and 2.77 inches fell during August--the third lowest on record. Our streams continued to yield water, in small quantities, and low points on the ground water depletion curves were established. Poor planting stock, coupled with the extreme summer drought, caused heavy mortality of white pine planted on Watershed 1 and, as a result, we lost about half the seedlings.

Along with our driest summer, we had, as did the rest of the South, our coldest winter during the past nine months. The temperature dipped to -4°F. at our Class A weather station, and at the higher elevations was below 0°F. for several days. One of the three major snowfalls amounted to 6 inches. Ice had to be chopped out of the ponding basins so as to avoid damage to the weir walls and to maintain accurate streamflow records.

## Meetings and Training Sessions

Whelan attended a Forest Hydrology Orientation and Training Meeting held at Clemson College on December 3-5, 1957. He also participated in an Inter-Agency meeting on the Delaware Basin development program in Philadelphia, September 30 to October 11 to prepare a plan for determining hydrologic condition of the Delaware watershed as of the present, 1975, and the year 2000; and in a meeting at Stearns, Kentucky, November 4-6, to examine private land involved in a court case on strip mining, adjacent to the National Forest land involved in the famous Stearns Case. (The case was settled favorably out of court and adequate reclamation measures are to be taken.) Other meetings: an Inter-Agency meeting on the Delaware Basin development program at Philadelphia, November 6-9; and the American Society of Agronomists Meeting (with Hewlett) in Atlanta, November 18-21. Hewlett also attended the Annual SAF meeting at Syracuse, November 11-15.

## Visitors

More than 400 visitors were shown the Coweeta area during the period. Included were Dr. H. C. Pereira of the East African Agriculture and Forestry Research Organization, Kenya, and Dr. F. Firat, Director of the Forestry Products and Economic Institute, Istanbul, Turkey. Several students and professionals from foreign countries have spent week-long training periods here. Training sessions were held for a total of 117 students from North Carolina State University, Syracuse University, Auburn, Western Carolina College, Emory University, and Junior Professionals from the North Carolina National Forests.

Publications

Dils, Robert E., "A Guide to the Coweeta Hydrologic Laboratory," Southeastern Forest Experiment Station, Asheville, N. C., 40 pp. illus. September 1957.

Whelan, Donald E., "The Effects of Land Use on Runoff," (address before the conference of the Alabama Academy of Science, Jacksonville, Ala., April, 1957), Journal of the Alabama Academy of Science, Vol. 29, Oct. 1, 1957.

Black, Peter E., "Interception in a Hardwood Stand." Thesis submitted to School of Natural Resources, University of Michigan, in partial fulfilment of the requirements for the degree of Master of Forestry. On file at Coweeta, 90 pp., illus.

PIEDMONT RESEARCH CENTER

October 1957 - March 1958

Soil Moisture Studies (FS-1-w1-6-SE)

An investigation was begun at this Center to determine the effect of thinning Piedmont stands on soil moisture. One objective of the study was to establish soil moisture depletion and recharge characteristics of a fully stocked loblolly pine plantation and loblolly pine plantations thinned to two levels of basal area. Average moisture conditions were determined by gravimetric methods twice weekly and after rains during the growing season.

First year results from a 16-year-old plantation show variation in depletion rates from different depths in the soil and from stands of different basal areas. Losses were highest at the surface and decreased with depth. Within each depth, losses were highest under unthinned conditions and decreased with lower basal areas. The surface foot of soil was reduced to the wilting point quite rapidly, all depletion curves being curvilinear (see Figure 1). Under thinned conditions, depletion curves for the 2-3 and 3-4 foot depths were linear, indicating that moisture was sufficiently high throughout the summer to prevent strong soil-plant moisture stresses from being developed.

Isolated points in the profile were sometimes at or slightly below wilting during the summer, but average moisture conditions below one foot were always above the wilting point.

Evapo-transpiration losses were related to basal area. Of interest is that moisture losses occurred in all plots to a depth of 96 inches. Listed are evapo-transpiration rates for the 0-4 and 4-8 foot depths for a specific depletion period.

| Basal Area per Acre | Average Daily Evapo-transpiration from April 23, 1957 to Sept. 3, 1957 for depths: | |
|---|---|---|
| | 0-4 feet | 4-8 feet |
| 150* | 0.147 | 0.172 |
| 75 | 0.140 | 0.146 |
| 45 | 0.121 | 0.133 |

*Unthinned

To determine the distribution of moisture between trees, samples were collected on November 8, 1957, at a time when soil moisture had been largely depleted and when antecedent rainfall amounted to only 0.69 inch for the preceding 28 days. Moisture samples of the surface four feet were taken at two-foot intervals, beginning about three inches from one tree and ending at the base of a second tree approximately 20 feet away. Some results contrasting soil moisture under trees and recently cut trees (stumps) are plotted on Figure 2. After felling, roots of the nearest adjacent trees and evaporation accounted for all moisture losses. The moisture content was highest mid-way between trees and lowest directly below the trees, and the three-inch difference in available water was significant at the .05 probability level. Meanwhile under nearby unthinned plantations, the moisture content remained relatively constant throughout the plot.

Recharge data were so variable that no dependable relationships could be established.

Figure 1.--Soil moisture depletion in the surface foot of soil under thinned and unthinned loblolly pine plantations.

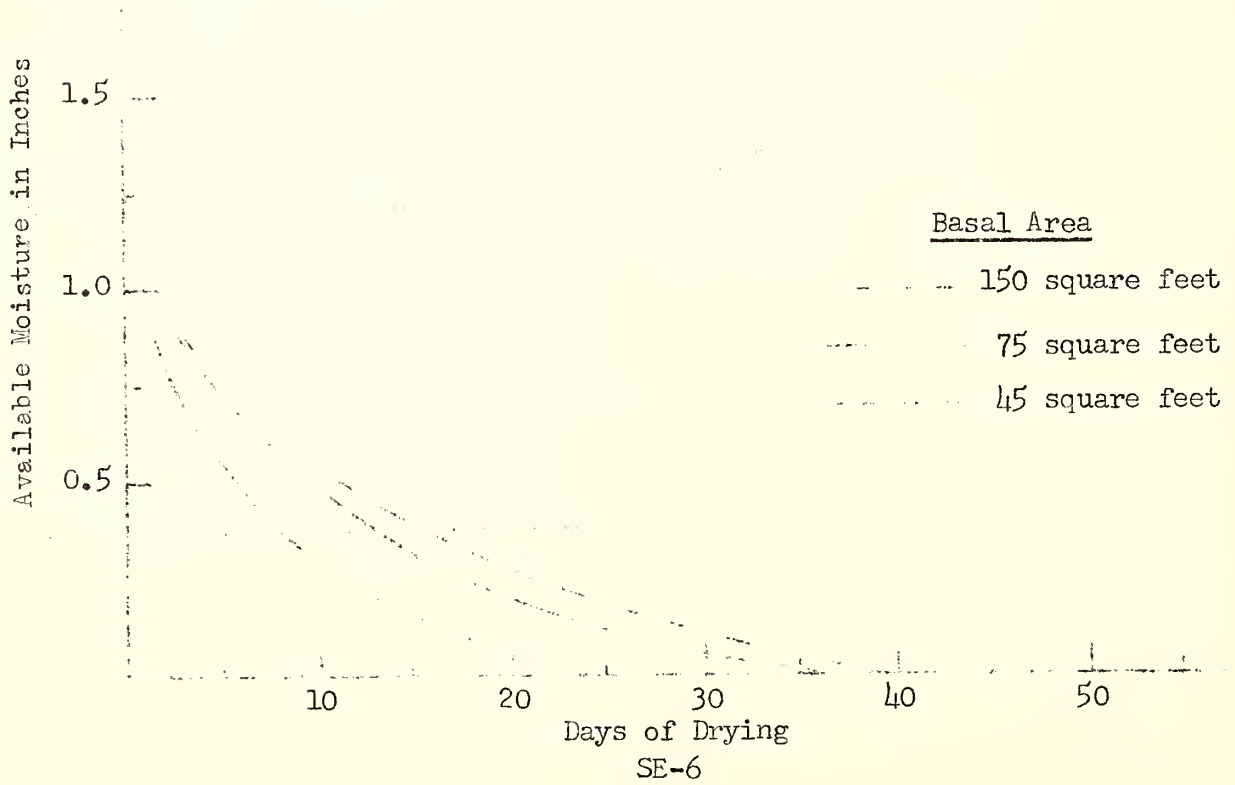
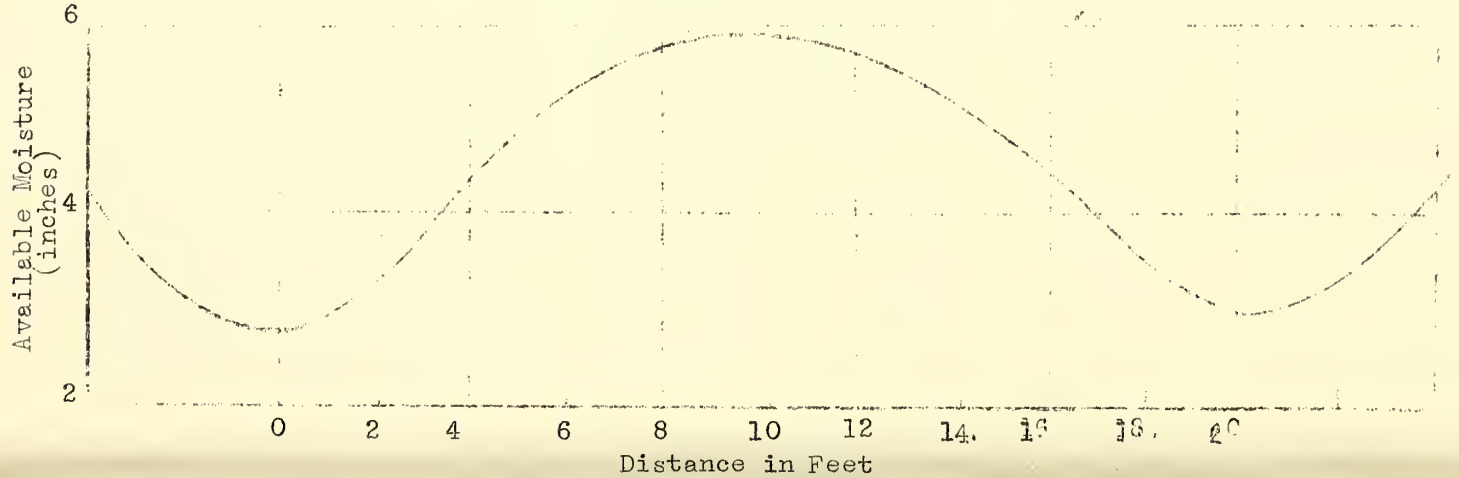


Figure 2.--Moisture distribution beneath a loblolly pine plantation at the end of the first growing season after thinning.




SE-7

Soil Fauna Project (FS-1-w4-1-SE)

A new study concerned with the fauna of forest soils in the S. C. Piedmont was started in June 1957. So far this is a cooperative venture between the Station and the Dept. of Entomology, University of Georgia. Byron Smith, a candidate for a Ph.D. at that school with special training in the field of micro-arthropods, is doing the taxonomy work. Samples of litter (where present) and the surface 2 inches of mineral soil have been collected at 15 different sites, ranging from eroded gully areas to old-growth hardwoods. Identifications have been made to at least the family level in the Annelida and Arthropoda phyla. No work is being done with fungi, bacteria, or nematodes. It is difficult to get suggestions in this field and so a lot of things are being done on a trial and error basis. For each site we collect five one-square-foot samples of the organic layers, and 25 cylinders of soil (each about 3" in diameter). Equipment used for soil sampling is that described in Southeastern Forest Experiment Station Paper No. 42. Fauna are extracted over a period of seven days in home-made Berlese funnels. One square foot of litter or 5 soil cylinders make up a load for the size funnels being used.

Over 99% of the specimens collected are Arthropods. We think we are missing a lot of worms because (1) all collections have been made during the day and it is during the night that the worms come to the surface to mate; (2) sampling has been confined to the surface 2" and even during the night probably a great number of worms stay below this depth; (3) soil samples are too small.

There are also several orders of insects generally missing from the collections. Some rapid moving insects, such as roaches, crickets, and grasshoppers, are difficult to collect with the sampling procedures used. Also, some of the beetles are long legged and rapid runners and could easily escape from either the litter or the soil samples.

It is obvious that various sized samples will be necessary to properly characterize the population of a site. Methods used so far are adequate for small animals such as the mites, ants, and collembola. Larger samples will be necessary for some orders and collections at night may be necessary for worms.

Collections made so far indicate that the number of fauna present under pine stands is greater than under hardwoods. Most of the pine stands do not have a humus layer present and under these conditions there are more animals present in the surface two inches of soil than in the organic layers. For example, under a 20-year-old loblolly pine plantation there were 226 animals per square foot of litter and 516 per square foot of soil. A pine stand with a well developed humus layer had 56, 1683, and 3286, respectively, for a square foot of the L, F, and H layers. Some animals appear to be about everywhere. On a severely eroded clay soil there were 23 animals per square foot and in a sand creek bed of an intermittent stream there were 34 specimens. An eroded clay area mulched with pine needles had 520 animals per square foot and a comparable area planted to sericea had 244.

After thoroughly sampling a variety of sites we hope to begin studying the feeding habits of certain groups of animals.

ERRATA

Semiannual Report, Division of Watershed Management Research, Southeastern Forest Experiment Station, Oct. 1957-March 1958.

The reference to 4-8 foot depths (last sentence and in tabulation, bottom of page SE-5) is incorrect. This should be 0-8 feet.

SEMI-ANNUAL REPORT
Division of Watershed Management Research
Southern Forest Experiment Station

October 1957 - March 1958

## General

The Arkansas Forest Survey was started in November 1957. Supervisory personnel will take diagnostic tallies and will record supplemental watershed and site productivity data on every 16th plot. Southern Station and Region 8 specialists will conduct a training session for Survey field supervisors in collecting hydrology-soil productivity data in early April 1958. Items to be included were described in the April-September 1957 semi-annual report, and have now been incorporated in Supplement No. 4 of Instructions for the Arkansas Forest Survey.

Ursic attended the 4th National Watershed Congress, Atlanta, Georgia, September 23-25 as the Southern Station representative, and participated in the Southern Station Pine Regeneration Research Conference at Alexandria, Louisiana, October 15-17.

## Personnel

Edmond Swensen, who has been with Vicksburg for five years, was scheduled to transfer to the Ozark National Forest early in April 1958. Louis E. Andrew, formerly with the Soil Conservation Service in Oregon, and recently with the Near East Foundation in Afghanistan, and Roger W. Rich, from the University of Massachusetts, reported to Vicksburg in October.

## Publications

### Manuscripts Published

Krumbach, Arthur W., and Stearns, Forest W. Summary of the Development of a Soil Moisture Prediction Method. Vicksburg Research Center. 40 pages, multilithed. Nov. 1957.

Stephenson, G. K. Hold that raindrop! Southern Lumberman 195(2441):162-164, illus. December 15, 1957.

Stoeckeler, J. H., and Thames, J. L. The Lake States Penetrometer for Measuring Depth of Soil Freezing. Soil Science 85(1):47-50. January 1958.

Thames, J. L., and Ursic, S. J. Improved Rain Gage Supports. Jour. Soil and Water Conservation 12(6): 283, illus. November 1957.

Vicksburg Research Center, Southern Forest Experiment Station. Forecasting Trafficability of Soils Report No. 4. Information for predicting moisture in the surface foot of various soils. U. S. Corps of Engineers, Waterways Experiment Station, Tech. Memo 3-331, 102 pp., illus. 1957.

Manuscripts in Preparation or Being Edited

Andrews, L. A., and Broadfoot, W. M. The San Dimas Soil Core Sampler. California Station. (Scheduled for early publication in Soil Science).

Broadfoot, W. M. A Method of Measuring Use of Water by Forest Stands on Slowly Permeable Soils. (Scheduled for early publication in the Journal of Forestry).

Broadfoot, W. M., and Burke, H. D. Soil Moisture Constants and Their Variation. (Ready for final editing).

Lee, Johnnie E. Tray and Counterweight for Aluminum-wrapped Soil Samples. (Submitted to Soil Science, Feb. 1958).

McClurkin, D. C. Soil Moisture Content and Shortleaf Pine Radial Growth in North Mississippi. (Submitted to Forest Science).

McClurkin, D. C. Maleic Hydrazide Fails to Control Fertilized Bermudagrass. (Submitted to Tree Planters' Notes).

Thames, J. L. Measuring Soil Moisture Over Large Areas With Single Installations of Soil Moisture Electrical Units. (At Branch for revision).

Thames, J. L. Hydraulic Inserter for Soil-Moisture Units. (Submitted to Soil Science).

Thames, J. L., and Ursic, S. J. A Temperature Regulator for Use in Forest and Agricultural Research. (In-Station review).

Ursic, S. J., and Thames, J. L. An Accurate, Practical, and Inexpensive Rain Gage. (Final editing).

Vicksburg Research Center, Southern Forest Experiment Station. Forecasting Trafficability of Soils Report No. 5. (Being processed).

## Central Ozarks Research Center

### Watershed Studies

A series of studies has been activated in northwest Arkansas to measure the hydrologic effects of conversion from hardwood tree growth to native range. Two runoff plots 12 x 100 feet have been installed in each of four cover-grazing complexes as follows:

1 - Woodland - not grazed.
2 - Woodland - grazed.
3 - Converted woodland to range - grazed half season.
4 - Converted woodland to range - grazed whole season.

The plots are located on a common aspect and a standard slope.

Data to be gathered from this study include:

1. Rainfall rates and amounts.
2. Total runoff by weekly periods.
3. Total erosion losses by weekly periods.

This study was superimposed on a cooperative study installed by the University of Arkansas. The schedule of operations precluded a calibration period, but a comprehensive soils study was installed to test the comparability of sites and the effect of conversion and grazing upon the soil hydrologic properties.

The pre-treatment soil analysis of the study areas indicated a very close correlation between sites. All sites tested showed consistently high infiltration rates. Volume weight and pore space distribution analyses, determined on 3 x 3-inch cores of undisturbed soil, showed a very close relation. The soil of the test area has a large amount of incorporated chert and gravel. Therefore it was necessary to correct volumes of soil for rock content. The close correlation obtained in this phase of the study was especially gratifying since almost all of the soils in the Ozark and Ouachita Mountains contain large quantities of loose rock. Before taking and processing these samples, the effect of rock content upon undisturbed soil core sampling and analysis in this area was unknown.

Volume weight, the relation between a given volume of undisturbed soil and its weight, is a sensitive measure of compaction. Volume weights for the soil cores extracted from the four sites averaged 0.70, with ranges extending from 0.67 to 0.73.

The average pore space distribution for all cores extracted amounted to:

Total - 61.00 percent
Detention - 25.00 percent
Retention - 36.00 percent

Textural analyses showed the following average:

Sand - 14.00 percent
Silt - 64.00 percent
Clay - 22.00 percent

Water stable aggregate analysis using the wet sieve method of Yoder gave a close correlation with the major portion of the aggregates remaining on the 1 and 2 mm. screens.

While organic matter content analyses have not been completed, physical inspection of the surface soil shows a considerable quantity of organic matter.

The changes in humus-litter character and amounts as well as soil moisture changes brought about by the change in cover and subsequent grazing are being investigated in two separate studies now under installation.

## Soil Moisture Studies

Studies in south Arkansas have shown that soil moisture deficiencies during dry years may stop tree growth as early as July 1, even on deep soils having a maximum water-holding capacity. Because moisture availability may be even more important in relation to growth on the shallow soils which characterize the mountain terrain in the Ouachita Region, similar work has been installed on an exploratory basis. The moisture use of typical stands of mixed pine with a hardwood understory, and pine with the hardwoods removed, are being observed. Weekly growth and soil moisture measurements will be followed for at least a two-year period. From a watershed standpoint, this study will provide data to be used in planning a future study measuring the watershed-wide effect upon late summer dry season water yields of wholesale timber stand improvement via elimination of hardwoods from pine stands.

## Tallahatchie Research Center

### Watershed Studies

Construction of the third battery of three small watersheds was completed and operations started as of January 1, 1958. The three natural drainage units are from 2 to 3.5 acres in size and have a good stand of loblolly pine planted 20 years ago on abandoned and heavily eroding old-fields. Soils in this study are similar to the soils on the three old-field watersheds, and the three watersheds supporting stands of depleted upland hardwoods. Instrumentation has been described in previous reports.

Soil mapping was completed on the first six watersheds (three on abandoned old-fields, and three on depleted upland hardwoods), and electrical soil moisture units were installed on each major soil type represented on the two cover types.

Runoff and sediment computations have been completed for the first nine-month period of operation on the three old-field installations. The composition and density of the ground cover shown below were determined by the line-interception method.

| | Watershed | | |
|---|---|---|---|
| Cover class | No. I | No. II | No. III |
| | -----Percent------- | | |
| Grasses, weeds | 9 | 13 | 7 |
| Litter | 35 | 36 | 17 |
| Bare soil | 56 | 51 | 76 |
| | 100 | 100 | 100 |

It is the occasional intense storm which moves quantities of soil from this soil-cover type (broomsedge-loess). The storm of April 3-4, 1957 is a good illustration. Soil losses from the three units during this 2.60-inch storm were respectively at the rate of 2.56, 2.19, and 4.64 tons per acre. These amounts represent more than 70 percent of the total sediment production for the nine-month period. Instantaneous peak discharges were at the rate of 1850, 1654, and 1887 c.s.m. Characteristics of this storm indicate a recurrence interval of about one year. By way of comparison, the greatest soil loss from the 23-acre mountain farm at Coweeta for an individual storm during a 20-year period which occurred while the area was in clean-row cultivation was at the rate of 3.26 tons per acre and the peak discharge 1849 c.s.m.

Storm runoff and soil losses for the three watersheds are summarized below.

| Watershed No. | Precipitation | Storm runoff[1] as a percent of precipitation | Sediment[2] production |
|---|---|---|---|
| | Inches | Percent | Lbs./acre |
| I | 42.45[3] | 32.2[3] | 7,050 |
| II | 44.35 | 18.8 | 5,890 |
| III | 40.54[3] | 18.3[3] | 13,190 |

1/ January 1 - September 30, 1957
2/ March 1 - September 30, 1957
3/ Excludes missing storms

The higher volumes of storm runoff from watershed I are believed to be due to the finer-textured soils, and to the presence of a shallow fragi-pan. Information on the perched water table caused by the fragi-pan is being obtained with a series of shallow wells.

## Land Rehabilitation Studies

Degree of root pruning.--Results of a two-year installation (one wet year-one dry) indicate that degree of root pruning has no significant effect on the first-year survival and growth of loblolly pine seedlings planted on adverse sites in north Mississippi. Roots were pruned to 4, 6, 8, and 10 inches and outplanted on droughty sands and compacted loessial soils.

Mulch requirements for pine establishment.--For the second year, results of field plantings after one growing season indicate that mulch has no significant effect on the growth and survival of loblolly pine seedlings planted on poor-risk sites. Survival of mulched seedlings was superior only on bare, cemented Coastal Plain material. This was due largely to the physical effect of the mulch which kept the soil around the seedlings in place. Seedlings on this site were washed out long before moisture became limiting. Seedlings were spot-mulched with hay and pine litter, and broadcast mulched with hay on droughty sands, eroded loess and Coastal Plain parent material. A consistently higher moisture content in the top nine inches of soil under spot-mulched seedlings (hay), as compared to the unmulched control, was apparent only on the sandy soils. There was also an apparent improvement in soil moisture in the 9-18-inch depth under mulch on sands.

Time of root pruning loblolly pine seedbeds.--Results of field plantings after one growing season indicate that root pruning nursery seedbeds did not consistently improve survival or height growth. Loblolly seedlings were pruned at 4, 6, 8, and 10 weeks prior to lifting and outplanted on droughty sands, favorable loessial sites, and adverse loessial sites.

Morphological grades of loblolly pine.--Results of the second-year installation help confirm the desirability of planting the better morphological grades of loblolly pine seedlings for erosion control in north Mississippi. Grades one, two, and three (cull) seedlings were outplanted on sandy and loessial adverse sites. Grade three seedlings in this study are the smaller and weaker-stemmed nursery shipped seedlings which, except for stem diameter, would qualify as grade two.

The first-year installation continues to reflect differences due to grade after two years in the field. Survival after two growing seasons averaged 76, 63, and 58 percent, and two-year growth averaged 2.3, 2.2, and 1.8 feet respectively for grades one, two, and three.

Depth of planting and pre-planting treatment.--First-year measurements of a study to compare the effects of shallow, and two degrees of deep planting; and watersoak and puddling treatments prior to planting were completed in October 1957. Both survival and height growth were significantly poorer for shallow planted seedlings. Pre-planting treatments had no apparent effect on field performance. Deep planting, one-half and three fourths of the stem, seems to stimulate height growth.

The study was reinstalled in March 1958. Survival will be recorded in June, and survival, growth, and vigor in October.

Lethal root temperatures of 1-0 loblolly pine seedlings.--A study to determine the temperature, temperature-duration relations lethal to loblolly roots was installed during March 1958. Roots were immersed in a constant-temperature water bath for 5, 30, and 120 minutes at temperatures ranging from $68^{\circ}$ - $139^{\circ}$ F. and outplanted. Additional lots were heated to simulate heating of packaged seedlings in transit and storage. Survival will be checked weekly. Final height and growth measurements will be recorded in October.

Post hole plantings as an aid in revegetating eroded land.--After two growing seasons the height of loblolly seedlings planted in topsoil-filled post holes on cemented subsoil was highly significantly better than that of mattock-planted seedlings. The effects of fertilizer and mulch sub-treatments were not apparent. Measurements are scheduled after the fifth growing season to determine if seedling roots have penetrated into the surrounding soil. An evaluation of the use of post hole plantings as a technique for revegetating adverse sites will be made at that time.

Species adaptability on adverse sites.--First-year survival of eight species and races of pine being tested for erosion control differed significantly, with sand pine from west Florida making the poorest showing. Height growth of loblolly pine was highly significantly better than the other species. Growth of two strains of Texas "Lost Pines" loblolly was greater than the average of two other loblolly strains from Georgia and Arkansas.

Differences in planting site apparently had no effect on survival. However, the average height growth of all seedlings was highly significantly better on areas with deep sandy soils.

Effects of transpiration inhibiting treatments and shading on loblolly pine survival on severe sites.--Dow wax sprayed on loblolly seedlings once during the growing season to retard transpiration neither increased initial survival nor affected height growth. Repeated sprayings when the soil was near field minimum, however, had a highly significantly adverse effect on survival. Average survival on plots sprayed three times during summer was only 57 percent of that on untreated plots. Shading seedlings alone and in combination with one application of Dow wax also failed to show any significant effects.

## Soils and Soil Moisture Studies

Grasses and legumes for erosion control.--Undisturbed soil cores from the study blocks are being taken and processed in the laboratory. Samples processed thus far indicate a measurable improvement in percolation on plots containing heavy grass or legume cover. There appear to be measurable differences in species as well, but none of these early opinions can be documented until all the lab work is completed.

Moisture and growth changes with thinning planted shortleaf pine.--During 1956 the statistical variables most closely correlated with radial growth were those dealing with elapsed days of growing season, total available moisture, and their interaction. In 1957--a year with a 15-inch rainfall surplus--radial growth was correlated with elapsed days of growing season, soil temperature, and soil moisture interaction variables. Radial growth response to thinning became most apparent the second year after thinning. During the second year, both thinned sites continued to grow through August while growth on the unthinned site leveled off by the end of July.

Fertilizer treatments on planted loblolly pine seedlings.--As yet there are no improvements in survival or height growth associated with either single or double applications of commercial fertilizers. Several seedlings were severely burned or killed by the second fertilizer application since the foliage was covered during application and no rain occurred for several days following.

Use of a wetting agent on loblolly pines planted on adverse sites.--A new commercial product called Aqua-Gro will be tested to determine its effect on seedling survival on sites that become dry and baked during summer. Once it has been applied, the function of the chemical is to coat the soil particles with a non-polar organic film which reduces the surface tension of water on contact. It is hoped that the wetting agent will permit summer showers to move readily into the soil even on dry eroded sites, so that the planted pine will derive a greater moisture supply from the periodic summer rain.

Effect of soil moisture and ground water level on tree radial growth.--This study will examine radial growth of cypress, ash, and redgum in an area that is periodically under the influence of a water table which reaches the surface. By use of fiberglas units and ground water wells, the soil moisture content will be observed to determine radial growth during times when the root systems are totally flooded, partially flooded, and free of the water table.

Two additional studies involving fertilizers have been installed during this planting season. One involves late season fertilization of seedlings in which the plots will receive a complete fertilizer in mid-July rather than early in the spring. This procedure was suggested by a recent German publication which stated that nitrogen absorption by pine is slow during the March-July portion of the growing season. (Mayer-Krapoll, Herman. 1956. The use of commercial fertilizers--particularly nitrogen--in forestry. Ruhr-Stickstoff, Aktiengesellschaft. Bochum, Germany. Translation). During the July-September portion of the

growing season, absorption is much greater. The author stated that grasses, clovers, and weeds had completed 98 percent of their nitrogen absorption by the end of June. So late season application may supply the nitrogen when the pines can best utilize it, and may avoid to some extent the troublesome stimulation of weed growth.

The second new study on fertilization deals with pole-size shortleaf pine. Selected trees in thinned and unthinned plots will receive fertilizer. The study areas are those which have been used for soil moisture-tree radial growth studies for the past four growing seasons, and the individual radial growth characteristics of each tree is well documented. Final results will contain information on the radial growth response of thinned and unthinned pole-sized timber in the presence or absence of a complete fertilizer.

Inherent physical characteristics of the major local soils affecting relative erodability.--Investigations are planned on this problem in the near future. A large number of possible factors such as colloid content, dispersion ratio, and moisture equivalent may show correlation with relative erosiveness. The biggest difficulty confronting us during this planning stage is: what measurement will we use as the erodability factor; or stated another way, what measurement can we use for the dependent variable in determining relative erosiveness? If any reader has a suggestion on this point, we would be grateful to receive it.

## Vicksburg Research Center

### Use of the I.B.M. Model 650 Digital Computer in Soil Moisture Depletion

Carlson, Rich, and Kennedy have been working on the large quantities of data on soil moisture, temperature, and strength gathered during the past several years on sites representing most of the United States, parts of Puerto Rico, and Alaska. Computation of a prediction, using an ordinary calculator, is a tedious operation which requires four to twelve man hours per site. Each time a modification is made, further time is required to repeat the calculations to evaluate the "improvement". The I.B.M. 650 speeds up the handling of data and makes possible large scale tests of the prediction system and modifications.

Development of the I.B.M. program required the construction of a flow chart detailing the steps for the machine in terms of choices and operations. The flow chart was next converted to a set of numerical instructions on punch cards used to instruct the machine. Tables, such as depletion tables, must also be punched on cards to be fed into the machine. In our soil moisture prediction system the machine must be programmed to restrict depletion and accretion to the limits specified on the site instruction card, to keep track of depletion between rains, to choose the proper depletion curves depending on the soil texture and season, and to select the proper accretion relations depending upon the moisture content of the soil and the amount of rainfall. Approximately three minutes are required to feed the instructions into the machine and following this site data may be fed in and the program will direct the operation for any number of sites.

To make a prediction, site data including field maximum moisture content, depletion factors, soil texture, beginning day moisture content and site number and identification are fed into the machine. This is followed by the cards carrying rainfall amounts and seasonal identification in days. The first day (transition day) for each seasonal depletion curve must be supplied to the machine when the day does not coincide with a rainfall day. In addition, any other day for which a prediction is desired is also supplied to the machine. Approximately five minutes are required to machine punch the necessary cards for a year's record on one site with approximately fifty rain days. Computation proceeds automatically and the predicted moisture contents before and after each rain are punched on cards by the machine. These cards are then fed into a listing machine to give a printed record of the compilations. The time necessary for making predictions on a typical site is about two minutes.

After three month's work in development and testing of the I.B.M. program and in coding all site information for punch cards, our computer program is beginning to pay off. Using the same site data and rainfall cards, changes can be made in the program and tested quickly. With simple changes in a limited number of day cards it is possible to test the effect of shifting the season, while, by altering the site data cards one can test the effect of changes in accretion or depletion relations. Work is in progress to include soil strength in the prediction program and to develop equations to replace the depletion tables now in use.

After the machine prediction has been made, we still manually test the results by comparing the deviations of the predicted from the actual. This process may be programmed for the I.B.M. 650 at a later date.

## Solar Radiation and Soil Moisture Depletion on Loess

The study started in 1954 by Lull, and recently completed by Stearns, demonstrated some provacative relationships between environmental factors and the rate of moisture depletion in the upper foot of soil. This study was undertaken in an attempt to discover which environmental parameters would be most useful in extending the Vicksburg soil moisture prediction system to areas where ground information was scarce or not available.

Weather factors are best related to soil moisture loss when soil moisture is plentiful. In order to test the relationship under favorable conditions, the useable record was arbitrarily limited to times when the soil moisture was greater than fifty percent of the range between field maximum and field minimum values. Since soil moisture records were taken only five days a week, some days on which rainfall occurred were excluded and the useable record was further limited.

Solar radiation showed less variability and better correlation with other factors if summations of the data were made for a period rather than for single days. Hence, a three-day sum of values was used in the correlations in this study permitting the record to bridge the two day weekend gap in soil moisture records. These restrictions resulted in only 30 useable periods during the course of the year of record, of which 14 were in the winter, 10 in spring, 4 in early summer, and 2 in late autumn.

Solar radiation data from an Eppley pyrheliometer and Gier-Dunkle total and net radiometers were recorded on moving charts by potentiometers. Average hourly values were determined and these were summed for each three-day period. The actinometer charts were read by totaling the squares in the chart below the trace.

Evaporation pan values represent the lowering of water height over a three-day period and anemometer values are in miles of air movement during each three day period.

Relative humidities were averaged for two hour intervals and summed for each three day period. Only daytime values were used. Vapor pressure deficit was determined by averaging temperatures taken at the same interval used for relative humidity, determining the deficit for each day and summing the three daily values.

The air temperature mean was the daily mean summed for three days, the air temperature maximum was the sum of the three daily maximum and the air temperature sum was the hourly temperature summed for the three-day period.

The soil temperature expression was the sum of the soil temperatures for the 1-1/2, 4-1/2, 7-1/2, and 10-1/2-inch depths for the first and last day of the period.

Soil moisture losses were expressed in inches of water for the 1 to 12-inch layer over the three-day period. Values were obtained by means of Colman fiberglas units at the 1-1/2, 4-1/2, 7-1/2, and 10-1/2-inch depths.

Linear regressions were first computed between the various weather factors and soil moisture loss to see which had the highest correlation. Groups of factors were then tested by multiple regression to see if correlation would be materially improved.

The association of individual weather or environmental factors with measured soil moisture loss is expressed by correlation coefficients below:

| Factor | Cor. Coef.(r) |
|---|---|
| Soil temperature | 0.791 |
| Evaporation pan | .790 |
| Solar Radiation (Eppley) | .760 |
| Air temp. - Sum | .636 |
| Air temp. - Mean | .599 |
| Air temp. - Max | .535 |
| Vapor Pressure Deficit | .521 |
| Evaporimeter | .483 |
| Relative Humidity | .214 |
| Wind | .075 |

Soil temperature and evaporation pan losses both appear closely correlated with measured moisture loss. These factors may be considered integrating factors since they reflect air temperature and solar radiation during the three-day period of measurement and for some time previous to it. The pan further reflects wind, humidity, and dew fall. Soil temperature influences the rate of evaporation and of water movement through the soil and into and through plant roots. Hence, these factors have higher correlations with moisture loss than other more specific factors, such as solar radiation and air temperature. Solar radiation is highly associated with moisture loss, whereas air temperature, which has been used widely to estimate potential evapotranspiration, shows coefficients somewhat lower. For air temperatures the best correlation with moisture loss is by the sum, next best by the mean, and the poorest by the maximum. Vapor pressure deficit shows a slightly lower correlation than temperature while relative humidity has a weak relationship.

Multiple regressions were run to see if groups of factors would materially improve correlation with measured soil moisture loss over that from individual factors, as shown below:

| Independent Factors | Multiple Correlation Coefficient |
|---|---|
| Soil Temp., Air Temp. Mean | 0.808 |
| Evaporation pan, Air Temp. Mean | .798 |
| Radiation, Air Temp. Mean | .770 |
| Soil Temp., Radiation, Wind, Humidity | .823 |
| Soil Temp., Radiation, Air Temp. Mean Wind, Humidity | .842 |
| Soil Temp., Evaporation pan Radiation, Air Temp. Mean Wind, Humidity | .843 |
| Soil Temp., Evaporation pan, Radiation | .831 |

No great improvement in correlation is gained when each of the three best individual correlators with moisture loss are grouped with air temperature mean. Air temperature does not appear to contribute much in these correlations. When soil temperature and solar radiation are combined with other factors there is a marked improvement in correlation. In these combinations, evaporation pan values increase correlation more than wind and humidity, but not as much as air temperature plus wind and humidity.

An evaluation of radiometers was also made by correlations as shown in the following tabulations.

| | Dependent Variable | |
|---|---|---|
| | Eppley | Moisture Loss |
| Radiometer | Correlation | Coefficient |
| Eppley Pyrheliometer | --- | 0.722 |
| Net Exchange | 0.968 | .682 |
| Total | .961 | .729 |
| Actinometer | .989 | .721 |

For correlations with the Eppley pyrheliometer as the standard and with soil moisture loss, all radiometers gave equivalent results for purposes of this study. The net exchange and total radiometers were least desirable because of their frequent shut-downs. The actinometer is considered adequate for the accuracy required in this type of study. The instrument costs less, requires no power source and is simple to operate. Actinometer charts were much easier to read than those of the recording potentiometers.

The standard evaporation pan with a correlation coefficient with moisture loss of .790 was superior to the Japanese evaporimeter, which had a coefficient of .483. The correlation between instruments was .685, much less than that between radiometers. The location of the Japanese evaporimeter, inside the weather shelter, as well as the construction of the evaporating surface, a filter paper fed by a wick, probably accounts for its inferior results.

In all cases, radiation is closely correlated with soil moisture loss. If radiation data were available on a wide scale, it would appear possible to make some use of it in extending the soil moisture prediction system. The close relationship of pan evaporation suggests another opportunity for the extension of the system, utilizing a meteorological factor, but reliable data are available for only limited areas.

It is not anticipated that further experimental work will be done at Vicksburg on correlation of radiation with moisture loss although it is planned to test the factors showing good correlation in the extension of the prediction system.

## Sampling and Soil Variability

We are very much interested in John Hewlett's discussion, "Soil Moisture Sampling by the Gravimetric Method: Is it Practical in Forest Hydrologic Research?" in the Semi-Annual Report, April - September 1957, pages SE 5-9. We are studying the sample and soil variation problem at Vicksburg since our moisture predictions depend upon proper textural classification of the soil and since we must sample frequently and in many portions of the country.

Krumbach is studying "Sampling Intensity for Determining Horizontal and Vertical Variation of Physical Characteristics on Selected Soils" in an effort to help answer the question of the number of samples necessary for adequate representation of a soil. The study is designed to determine the range of variability in bulk density and moisture content as well as soil strength, organic matter content, texture and moisture tension values, within soils of similar genetic origin. We have begun with loessial soils since they are close at hand and represent a trafficability problem. Although the material from which they are formed is all of fine texture, there is sufficient opportunity for variation to make a sampling study on these soils. The first step was a pilot study with "complete" sampling of a plot on a loessial bottom soil subject to occasional inundation. We are now sampling soil areas of similar slope and position in Mississippi and later will plan to study loessial soils of Central United States and possibly of the Palouse region of Washington.

Upon completion of this study, we hope to have answers for the following questions:

1. What is the magnitude of variation of physical properties, horizontally and vertically, within soils with similar slope, aspect, and cover conditions.

2. Is it possible to sample the various physical properties within practical and acceptable units?

3. What spacing interval may be used to properly describe a soil or soil group?

In the pilot study, a 50' x 60' plot with one hundred twenty 5' x 5' squares were used. One quadrant was randomly selected in each square. Each of the physical properties previously mentioned was sampled to a depth of 18 inches.

Analysis has been completed for bulk density, moisture content, tension values, and the strength tests with results as follows:

| Depth | Bulk Density Mean | Standard Deviation | Significantly different from: (t= .05) | At saturation, Samples needed for accuracy of + .10" $H_2O$ per 6" Soil (t= .05) |
|---|---|---|---|---|
| 0"-3" | 1.259 | 0.075 | All other depths | 10 |
| 3"-6" | 1.309 | .064 | 0-3, 9-12, 15-18 | 8 |
| 6"-9" | 1.318 | .062 | 0-3 | 7 |
| 9"-12" | 1.326 | .063 | 0-3, 3-6 | 7 |
| 12"-15" | 1.321 | .080 | 0-3 | 11 |
| 15"-18" | 1.340 | .060 | 0-3, 3-6 | 7 |

Spacing interval: Any interval up to 50 feet.

The difference between the surface horizon and the rest of the depths is to be expected. Also, the fact that there were no differences between any of the horizons below 6 inches might be expected.

A pleasant surprise was to find that at saturation, the mean of eleven samples would be within ± .10 inches of the mean water content per six inches of soil. About half that number of samples would be within ± .15".

Spacing determinations were made only in the 6"-12" depth, as that is the depth whose strength determines bearing capacity of the soil for vehicles. The analysis showed that the distance between samples does not matter up to 50', the maximum distance to which the effects of distance between samples was tested.

The moisture samples were taken in about three hours on one day. The 0-6 inch depth is the most variable. In this analysis, it was found that distance of samples from each other did not matter up to 45' apart for the 6-12" depth. To sample within 0.1" of the actual moisture content per six inches of soil, 16, 12, and 10 observations were found to be necessary for the 0-6, 6-12, and 12-18 inch depths, respectively. Average moisture content was 30.17% by weight, or about 85% of saturation.

Moisture content was determined for 15, 30, and 60 cm. tension values. As the results were similar for all three tension analyses, the 60 cm. results are presented here.

The 0-3 and 3-6 inch depths are the most variable. The mean of each of these depths is significantly different from every other depth and the number of samples necessary to get within ± .1 inch of water are as follows:

| Depth | 0-3 | 3-6 | 6-9 | 9-12 | 12-15 | 15-18 |
|---|---|---|---|---|---|---|
| Samples | 29 | 19 | 11 | 10 | 12 | 6 |

Twenty-nine samples to get within ± .1 inch of water for the surface three inches makes sampling prohibitive. Fortunately, we are primarily interested in the 6-12" inch depth, and eleven samples appears to be adequate. Again, for the 6-12 inch depths, sample spacings could be an interval up to 50'.

What this means is that in the next step of the study, we may be able to use no more than twelve samples on each soil selected at random spacing intervals up to 50 feet which will permit us to check on the validity of our original analyses, and make any corrections necessary.